THE

LAWS OF THE WINDS

PREVAILING

IN WESTERN EUROPE

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BY W. CLEMENT LEY.

With Charts, Diagrams, etc.

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CHAPTER I.

INTRODUCTORY.

THAT Meteorology should be in our own country a popular science is the natural consequence both of the variability of our climate and of the national importance of every subject connected with maritime affairs. It would indeed be remarkable if in Great Britain the phenomena of the weather did not constitute one of the most favourite subjects of scientific investigation. And accordingly we possess an exceedingly numerous body of meteorologists, exhibiting a profound acquaintance with all the minutiæ of local weather observation, and prosecuting with great ability and perseverance the laborious study of one of the most intricate of sciences.

It may appear therefore a matter of surprise that among so large a staff of observers so few have been found to attempt the task of investigating the greater problems of General Meteorology, and of discovering and defining the laws which regulate the development, progress, and connection of the great systems of atmospheric circulation, the relative position and interdependence of the various areas of high and low pressure, and the influences of the general distribu-

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tion of heat and cold, and of the processes of evaporation and precipitation, as the motive forces of the atmospheric fluid. Our surprise is lessened when we consider the extremely abstruse character of the inquiries involved in dynamical meteorology, and the almost interminable complexity of the conditions which influence the motions of the atmosphere. So great undoubtedly are the difficulties in which the subject is involved, that it requires a certain degree of scientific enthusiasm to believe that they are not insurmountable, as well as of indefatigable assiduity to endeavour to grapple with them.

The very partial degree of success which, in spite of their possession of these qualities, undeniably attended the labours of the most eminent of the earlier investigators in this branch of science may have also exercised a deterrent effect upon those willing to undertake the task. The history of meteorology has indeed exemplified in a special degree the truth of Bacon's remark respecting the inductive sciences in general, "Intellectui non plumæ addendæ, sed plumbum et pondera," by the failure of many theories which have been too crudely put forward, and of generalizations which have been too rapidly made in the effort to simplify the expression of the laws of atmospheric motion. Of still more injurious influence has been the too persistent adherence to the method of statistical research in the endeavour to discover periodicities, systems of cycles, and the like; and the abortions of weather prediction, arising out of these premature attempts, have tended to bring the science itself into the disrepute which should of right pertain to the theories of the weather-wizards.

It is satisfactory, however, to observe that a healthy reaction has recently set in in favour of the more la-

borious investigation and analysis of the subjects of dynamical meteorology. Science works out the cure of its own maladies, and the failure of some of its earlier theories commonly furnishes the basis of the most valuable of later generalizations. Meanwhile the extension of the system of simultaneous observation under the able superintendence of the Meteorological Committee in England, and of the other meteorological services established in Europe, coupled with the all-important and rapid progress towards perfection in the instrumental department of the science, furnish ground of confidence that the difficulties of general meteorology will ultimately be to a great extent overcome, and that the laws of wind and weather will very shortly be more completely understood, and more accurately defined than they can be said to be at present.

There can be no question that the constantly accumulating testimony to the invariability of Ballot's law, connecting the direction of every surface-wind with the distribution of surrounding pressures, has greatly modified in the course of the last few years the most received of meteorological theories. The general fact that winds blow in directions nearly parallel to the isobarics, having the highest pressure on the right and the lowest on the left of their course in the Northern hemisphere and the contrary in the Southern, no longer needs demonstration, being now an accepted law: but it is only very recently, and that in a very unsatisfactory measure, that its bearing upon some of the earlier conceptions of the science has received attention. When two classes of phenomena are supposed to co-exist or to follow one another only occasionally and in a variable degree, it is natural to assume that the one is only accidentally or by a secondary kind of causality connected with the other, but as

soon as the invariability of their co-existence is demonstrated a direct relation of cause and effect is indisputably established. According to the older theories of primary (polar and equatorial) currents, the baric conditions of the atmosphere were necessarily interpreted as being, at least in many cases, the variable results of the atmospheric currents, but now that the uniformity of the rules connecting these phenomena has been established, it becomes necessary to assume, in a general way, the baric condition as the cause, and the current distribution as the effect, and the general laws of wind and weather have to be to some extent investigated *de novo*. Such statements as the following, "in the storms of the temperate zone, when the equatorial current is forcing its way onwards, the barometrical minimum is advancing in the direction of the current, and the air accordingly is flowing towards a district in which the barometrical level is relatively higher than in that from which it has travelled,"* or, again, "the highest barometer is about midway in the polar current, the least tension about the middle of each tropical current,"† are now necessarily admitted to be erroneous; but it does not seem to have been sufficiently observed that the ideas which they involve are not merely excrescences of the system of meteorological dynamics advocated by their authors, but appear to a great extent to underlie that system. The whole theory according to which the varying types of atmospheric circulation are regarded as resulting from the mutual collision, impact, overlapping, and diversion, of the primary currents, is gravely interfered with by the universality of Ballot's law. Similarly the distinction between cyclonic and non-cyclonic winds may be

* Dove, 'Law of Storms.'
† FitzRoy, 'Report of the Meteorological Office,' 1864.

said to have fallen to pieces, and the old battle between the "cyclonists" and their opponents, if renewed at all, would have to be fought over upon a totally new ground. Henceforth the investigation of the atmospheric currents resolves itself primarily into an examination of the configuration, extent, and interdependence of the baric areas, and the endeavour to discover the rules which govern the development, advance, or alteration of the latter must be regarded as preliminary to every inquiry into the laws of the resulting winds. The adoption of this method of inquiry in some of the most important recent treatises has already contributed a most valuable impulse to the progress of the science.

In the prosecution of these investigations it is requisite, while bearing in mind with strict scientific conservatism the various classes of facts which previous observers have accumulated in this branch of the science, to avoid the trammels of preconceived theories in support of which they have been adduced. It is necessary also, in the endeavour to discover causes, to be especially cautious of relying too much on the analogy between phenomena, however apparently similar, occurring in different and remote latitudes. It should be borne in mind that many meteorological phenomena bearing a close resemblance to each other in their characteristics when fully developed, may yet originate in different regions of the globe from the most diverse of conditions. Take the case of an ordinary rotating storm developed upon the shores of Western Europe. Observers appear constantly to assume the dependence of such a phenomenon upon conditions analogous to those which are believed to produce the cyclones and typhoons of tropical latitudes, and content themselves by attributing its existence to the resistance offered to the poleward

motion of a tropical current, or, as others, to the collision of two currents, a polar and equatorial, advancing against each other in opposite directions. They thus neglect the minute examination of the dynamical conditions actually preceding the formation of the system of disturbance, which would in many cases have revealed the non-existence of these assumed causes.

A system of daily weather-charts compiled from the various meteorological returns, maintained in a regular series for a considerable number of years, and accompanied by a continuous record of the alterations of pressure and temperature daily taking place over a sufficiently extensive geographical area, is indispensably requisite as the basis of these researches. By no other means is it possible to present to the apprehension the most important variations of the atmosphere as regards the baric, thermal, and hygrometric conditions, the direction, curvatures, force, and intensity of the currents, &c.; and when any of these cannot be conveniently exhibited to the eye in a chart, they should be compared, analyzed, and formulated in an appended table. It follows from the remarks already made that in the construction of the daily synoptic charts the correct delineation of the isobarics is the element of primary importance; and in comparing the results of the observations of successive days or periods, the alteration in the configuration, extent, and geographical position of the same will have to be most carefully attended to. It will be found that a particular class of baric areas (or the atmospheric spaces bounded by the isobaric lines) advance in one direction or another, with some degree of regularity, during a period of variable duration. This direction may be conveniently represented in the charts by a large arrow, the geo-

graphical space traversed in each interval of twenty-four hours being exhibited in the length of the latter. Directly any important change is noticed in the direction of the atmospheric progression, it should be carefully registered. The mean direction of these arrows should be from time to time carefully examined, and the result exhibited on a separate chart in the form of a line expressing the mean direction of the progression during the period. These charts again should be at longer intervals compared, and when the observations have been carried on for several consecutive years, it will be found that there are certain seasonal as well as geographical variations in the direction of the lines of atmospheric progression. These may be finally exhibited as the lines of mean seasonal (monthly or quarterly) atmospheric progression.

Again, it will be observed that on a comparison of a sufficiently large number of daily synoptic charts certain peculiar conformations of the baric areas, with corresponding systems of atmospheric currents, are constantly reappearing, though with modifications dependent in each instance upon pre-existing atmospheric conditions. These conformations should be especially examined, and the most marked of them selected as typical systems, the various approximations to which must be noted whenever they recur, and the deviations from the prevalent type classified and arranged.

The inquiry into the fundamental laws of the great atmospheric changes branches out into a very large number of collateral investigations, the topics of some of which will be discussed in the subsequent pages.

The author is aware that the subjects treated of in the present volume are undergoing the examination of abler physicists than himself; the result of whose

labours may be confidently expected to establish on a firmer basis than he can hope to erect, the primary laws of dynamical meteorology. But in a branch of science which is as yet only emerging from infancy into childhood, the work of every observer who brings a sufficient amount of assiduity to his task may contribute something to the general result. He has himself been engaged for some years in the prosecution of a system of investigation such as that above described. The labour of an arduous and incessant task will not be unrequited if the conclusions arrived at serve in any degree to further the progress of the science; and even if some of the propositions laid down should hereafter, as so frequently happens, be proved to be incorrect, or if for the causes to which the observed phenomena are attributed, others of a more satisfactory character should be substituted, it will be ample compensation to have assisted in directing the attention of observers to subjects which have hitherto been inadequately investigated.

CHAPTER II.

SYNOPTIC WEATHER-CHARTS.

As the system of mapping out the weather conditions is one of the greatest importance in itself, and as the explanation of the various symbols which it has been found convenient to employ in the synoptic charts would form an interruption to the course of our remarks when we come to examine some of the typical instances, it appears advisable to subjoin a single specimen selected from the volumes of the daily charts, with the necessary explanatory notes. The chart selected is that for March 14th, 1869.

The dotted lines represent in all cases the isobarics. As it is of importance to be able to take in at a glance not merely the *relative* distribution of pressures but the *actual* baric pressure over each region, the principal isobarics, that is to say, the 28·5, the 29, 29·5, 30, and 30·5, are in every case *coloured*, a system which has also the desirable effect of attracting the eye towards the general pressure distribution, giving to the latter an apparent importance in the synoptic view approaching to that which it really possesses in the dynamics of the weather. This plan possesses other advantages, which may appear as we proceed.

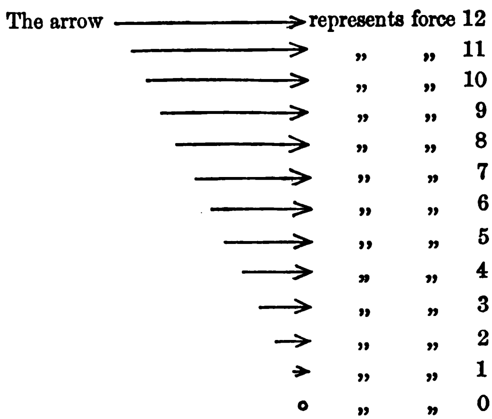
In all the charts the principal isobarics are coloured as follows:—28·50, orange; 29·00, green; 29·50, red; 30·00, blue; 30·50, brown.

In some of the charts these only are given. In others

the lines of intermediate pressures, commonly those representing quarters of an inch of mercury (29·75, 30·25, &c.). Any others might of course be selected. Thus in the specimen chart, Plate I., the isobaric 29·90, extending from Skudesnæs to Dublin is exhibited, as tending to show the decrease in the steepness of the barometric gradient towards the N.E., and to call the attention to the fact that the nucleus of highest pressure does not in this instance occupy the central portion of the region of high pressure.

The baric maxima and minima are in all cases represented by the capitals A and B respectively. (Thus in Chart I. the locality of highest baric pressure was on the west coast of Scotland, and those of greatest depression were in the Bay of Biscay and in the Alps.) When either the maximum or minimum does not fall actually within the limits of the chart, but slightly outside these (as is the case in this instance with the Alpine minimum), the position in which it is to be sought is pointed out by two converging lines ═ drawn on either side of A or B, which, continued to their point of meeting, will show the locality of the maximum or minimum. When the exact position of the maximum or minimum cannot be discovered from the meteorologic returns published in the daily papers, from those in the 'Bulletin International,' or from other data at hand, as, for example, when it occurs on the surface of the ocean at no great distance from our shores, it must be approximately determined by anemological considerations. The principles of these will be hereafter explained; it is sufficient to say here that it will commonly exist at, or near, the point where the radii of the curves of the nearest determinable isobarics would be found (if continued) to meet.

The smaller arrows represent the direction and estimated force* of the surface-winds. The standard of length most conveniently adapted to Beaufort's scale of 1 to 12 (a scale which must be for the present adhered to, as in most general use, though miserably inconvenient from a scientific point of view), is that of an inch divided into twelfths, thus:—



A small circle designating a calm.

The broad arrow, , represents, as already stated, the direction taken by the baric areas, its length giving the distance traversed in 24 hours, when discoverable.

The red arrows represent the direction of the cirrus current, when this can be determined. This is an element of too great importance in all weather observations to be omitted, when such omission is avoidable, in the synoptic charts. The length of these arrows

* When the time (an auspicious one for meteorology) arrives, in which daily anemometrical reports will be issued from numerous stations, in lieu of the present "estimated forces," the *distance* traversed by the current *per hour* will be most conveniently represented in wind-charts by the length of the arrow, and the charts will then exhibit to the eye with fidelity the motions of the surface-winds.

represents the space traversed per hour by this current, approximately determined by a method hereafter to be described.*

Currents of intermediate altitudes (which are also most commonly intermediate in direction) must not be delineated in the charts, but when of sufficient importance to render it desirable may be registered in an appended table.

The capital E is employed to designate the regions where evaporation may be assumed to be taking place in largest amount, this being determined by considerations of temperature, and the tension of aqueous vapour drawn from hygrometric returns. The principal regions of precipitation are denoted by the capital P.

Mean isothermals, when temperature differences are sufficiently well defined to render their delineation possible (as was not the case on the day selected in Chart I.), are represented by black continuous lines, ——. Otherwise, mean temperatures are sparsely expressed in figures upon the charts.

Local weather is marked by the initial letters of Beaufort's popular system of notation, which are dotted about upon the chart at discretion.

The objects which should be aimed at in the adoption of any system of weather-charts are in every case,—1st, the bestowal of greatest prominence in the synoptical view to those features which are of highest importance; and 2ndly, the avoidance of such minutiæ as are apt to introduce an unnecessary complexity, and to confuse the general view. The former end, which is too frequently neglected, appears to be secured in the scheme proposed. With reference to the latter, experience has

* Page 163.

shown that though the charts may appear on a first examination confusing, a very limited proficiency in their employment renders any person capable of comprehending by them at a single glance even the more complicated systems of atmospheric circulation.

CHAPTER III.

PROPOSITIONS.

FROM the constant analysis, comparison, and classification of such a system of daily weather-charts certain propositions have been deduced. Those which form the subject-matter of the first Part of this work will be here submitted, to be referred to and discussed in its pages. Some of them may seem to be little more than resolutions of Ballot's rules; others have already received a certain amount of examination at the hands of Mr. Buchan, Professor Mohn, and other meteorologists, while the remainder will appear novel generalizations. These will be all stated together, being all the results, on the author's part, of purely independent investigation, being mutually connected, and presenting, with those to be described in the later part, a tolerably complete system of anemology.

But few of these admit of statistical proof, their nature precluding the satisfactory employment of figures as means of demonstration; but where possible, tables illustrative of their degree of accuracy will be given in their appropriate places.

I. Baric Areas, or the atmospheric spaces enclosed in isobaric lines, tend as a general rule, in temperate latitudes, to circular or oval forms.

These forms are most nearly approached in the areas

of lowest pressure, while irregular figures are common in those of high pressure.

II. Baric Areas are naturally divided into two classes, *viz.* A, those whose currents revolve *directly* (or *with watch-hands*) in the Northern hemisphere, and the contrary in the Southern ("Anti-cyclonic"); and B, those whose currents revolve in a *retrograde* direction (or *against watch-hands*) in the Northern hemisphere, and the contrary in the Southern ("Cyclonic").

All areas of higher pressure than that of the surrounding regions are invariably of the former class; all areas of lower pressure than that of the surrounding regions are invariably of the latter.

III. Areas of depression tend to move, in extra-tropical latitudes, with a more or less rapid eastward progression.

Areas of high pressure when of small extent commonly follow the progression of neighbouring depressions; when of large dimensions, progress with much less rapidity, are frequently erratic, and sometimes for a prolonged period stationary.

IV. The direction of progression commonly varies in Western Europe between N.N.E. and S.S.E., and is primarily dependent on the general antecedent distribution of surrounding temperatures, every depression area tending to advance at an inclination of about 45° towards the lower mean isothermals.

This progression is, however, frequently interfered with, for

V. Mountainous districts, as well as certain coast lines, exercise (1) an attractive, and (2) a detentive influence upon depressions.

VI. Extensive areas of very high pressure check, divert, or accelerate the motion of depressions, every

depression progressing with greatest facility in the direction in which it has the highest general pressures on the *right* of its course (in the Northern hemisphere, and the contrary in the Southern).

VII. Depression areas are dependent both for their original development and subsequent expansion on precipitation, which is also the medium through which the forces described in Props. IV. and V. operate.

Heavy and extensive precipitation invariably precedes their first formation, and accompanies their expansion, and its cessation immediately precedes their collapse or dissipation.

VIII. This influence of precipitation, as a disturbing or motive power in the lower regions of the atmosphere, commonly varies inversely as the general temperature of the atmosphere.

IX. The upper currents of the atmosphere, while tending, in a general way, to move with the highest pressures on the right of their course, but depending in this respect on the more extensive pressure systems, and being comparatively unaffected by very limited baric areas, yet deviate considerably from Ballot's law, for

X. Upper currents manifest, in a large percentage of examples, a distinct centrifugal tendency over the areas of low pressure, and a centripetal over those of high.

XI. The axis of a progressive depression commonly inclines backwards.

Some remark is requisite in this place on our application of the terms "direct" and "retrograde" to the atmospheric currents. It is necessary to state that these expressions will be employed throughout to signify the gyration or curvature of currents as they appear

delineated upon a synoptic chart, with no reference to the totally distinct subject of the rotations of the vane consequent on the changes in the geographical disposition of the pressure centres. Thus, *e.g.*, a current which exists as a N.W. wind at Valentia, a W. at Cork, and a S.W. at Holyhead, will be termed a "retrograde" current; a current which exists as a W. wind at Valentia, a N.W. at Cork, and a N. at Penzance, will be termed a "direct" current; without reference to the preceding or subsequent changes of the winds in those localities. The attention paid to statistics of the rotations of the vane, these rotations being considered *independently of the progress and alteration of baric areas*, has been a great element of confusion in anemological research.*

The broad natural distinction existing between those baric areas whose currents are, in the sense above defined, direct (in the Northern hemisphere), and those whose currents are retrograde (in the same), forms a convenient basis for separate examination in detail; and to this distinction when there is added the almost equally important one expressed in Proposition III., it will be seen that the laws which regulate the systems of direct and retrograde currents are to some extent dissimilar, and admit of distinct investigation. It will be found convenient to consider in our first Part the characteristics of the areas of depression, whose currents in the Northern hemisphere are retrograde, and whose progression is more or less rapid in an Eastward direction.

* On this subject the remark of FitzRoy ('Weather-book,' p. 36) is most true: the results of registering and combining as direct or retrograde the gyration of the wind (from observations of the vane) "are unsatisfactory, because whether the wind runs directly or retrogrades is consequent on the central part of a circulating portion of atmosphere passing on one side or the other of an observer."

In the second Part of this work we shall proceed to describe the laws which regulate the areas of high pressure, the prevailing relative distribution of the areas of both classes, and the modes in which they appear to be interdependent, and finally the relation between baric differences and the force of the resulting atmospheric currents.

CHAPTER IV.

DEPRESSION SYSTEMS.

SEVERAL of the propositions in the preceding chapter are ultimately dependent upon the following primary law, which is indeed so obvious as scarcely to need demonstration, but which requires to be clearly comprehended at the outset by the student of meteorology. "Every extensive * centripetal motion in the atmosphere tends to become, through the influence of the earth's rotation, a helix, the currents of which are retrograde in the Northern hemisphere and direct in the Southern. Every extensive centrifugal motion tends to become a helix, the currents of which are direct in the Northern hemisphere, and retrograde in the Southern."

To confine our attention for the present to that portion of this law which refers to centripetal motions. It is obvious that in the case of three separate points existing in the same meridian, the rotation of the earth being greatest at the equator and diminishing to zero at the poles, the point nearest to the equator will be travelling from W. to E. with greater velocity than the middlemost of the three, and the latter again with greater velocity than that nearest to the pole. Suppose these points to exist in the Northern hemisphere, and at

* The term "extensive" is important, for in the case of very limited centripetal motions the effect of the earth's rotation is so slight as to be masked by other influences. Thus no law of gyration appears traceable in local whirlwinds, electrical or otherwise, trombs, waterspouts, &c., the direction in which these revolve being variable in either hemisphere.

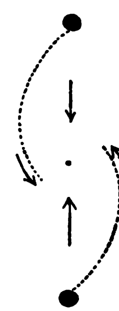
the middle point let an attractive force of any description be exerted upon bodies existing at the other points. The Northernmost of the latter will leave its position in a course the direction and velocity of which is the resultant of the motion imparted by the earth's rotation and that derived from the attracting force, but this course will be *apparently*, relatively *i. e.* to the more and more rapidly rotating surfaces over which it passes, a motion nearly to S.W., and it will accordingly tend to leave the centre of attraction on its left. Again, the Southernmost of the attracted bodies rotating as it does with greater velocity from W. to E. than the centre of attraction, will take a course which is the resultant of the motion imparted to *it* by the earth's rotation and of that communicated to it by the force of attraction; but this course will be, relatively to the more and more slowly rotating surfaces over which it passes, nearly N.E. in direction, and this body also will consequently tend to leave the centre of attraction on its left.

On the other hand, if the three points existing in the same meridian be in the Southern hemisphere, the most Northern will be travelling with the earth's rotation more rapidly than the central, and the central one more rapidly than the most Southern. In this case, a body existing at the most Northern of the three, if attracted towards the central point, will tend to pass to the Eastward of the latter, consequently leaving it on the right of its course, and a body attracted from the most Southern point will tend to pass to the Westward of the same, thus also having the centre of attraction on its right.

As a popular illustration, imagine a person situated at Portsmouth to be capable of attracting towards that point, with very little friction from inequalities of the

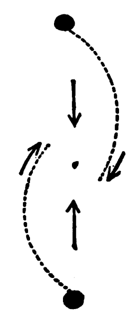
earth's surface, two balls, as in Fig. 1, the one existing at Aberdeen, on the west coast of Scotland, the other at Rochefort, in the Bay of Biscay. The former of these is, previously to the exercise of the attracting force, travelling with the earth's rotation from W. to E. with less velocity than the centre of attraction itself; which is in effect the same as if the centre of attraction were stationary while the ball at Aberdeen were travelling from E. to W. This body will accordingly commence to move in a direction nearly S.W., and will pass to the W. and S. of Portsmouth, being constantly drawn closer to that locality as it progresses. The ball supposed to exist on the coast of France will on leaving that region take a course nearly to the N.E., and will pass to the E. and N. of Portsmouth, with a motion still inclining towards the centre of attraction. The revolutions made by the attracted balls will consequently be of the retrograde description.

FIG. 1.



In Fig. 2 the attracted bodies are supposed to exist in the same meridian, but in the Southern hemisphere. In this instance, the Northernmost having a greater velocity of Eastward motion communicated to it by the earth's rotation than that possessed by the attracting centre, will consequently pass to the East of the latter; and the Southernmost having less velocity of Eastward motion, will be carried to the W. of the same. The motion of the attracted balls will therefore be direct.

FIG. 2.



Substitute for the supposed attractor a baric minimum (how produced we must presently proceed to inquire), for the imaginary balls the sur-

rounding portions of the atmospheric fluid, and for the attracting agency employed the efforts of the latter to regain the condition of equilibrium, and we possess a general idea of the character of the atmospheric circulation around an area of depression. In this case we have in the place of two bodies located to the N. and S. of the attracting influence, a homogeneous fluid surrounding the latter on every side. Only those particles of this fluid which exist in the meridian of the baric minimum tend directly to circulate in the manner and degree described. Those which exist on either side of the meridional line have less gyration directly imparted to them by the influence of the earth's rotation in proportion to their distance from that line; and those which exist in the same latitude with the baric minimum have no such motion directly imparted to them at all, and would flow in a straight line from W. to E. into the depression if their course could be independent of that of the neighbouring portions of the atmosphere. Indirectly, however, through the lateral impact and attraction of the surrounding portions, these also are thrown out of their immediate course, and there is thus established a system of atmospheric circulation, the currents of which tend to flow in a spiral into the region of greatest baric depression.

It is a corollary of what has been said that "cyclones" are not possible (as, indeed, they are not found to occur) at the equator.

General Characteristics of Depression Systems.

Areas of low pressure present the following characteristics, which, as exhibited in the exceptionally intensified form of "cyclonic storms," have long been the study of observers. As already described they approximate commonly to a circular form, and having a central calm with currents revolving around it, in accordance with Ballot's law, they resemble an extensive atmospheric vortex. This vortex is progressive, commonly advancing in extra-tropical latitudes in an Eastward direction. Simultaneously with its progress it usually undergoes expansion. Originally of small, it assumes in the course of its advance very large dimensions; the central portion not unfrequently attaining a diameter of several hundreds of miles, and containing light and more or less variable winds which only tend to circulate slowly, while the currents of its exterior arcs continue to flow with considerable rapidity, but with curves of so great a radius that their gyrating character is often unobserved, and the storms which they produce are frequently described as "non-cyclonic." Finally this wide-expanded wind-system becomes dissipated, pressure rising in an irregular manner in the more central portions, while a sort of collapse of the revolving currents of the circumference begins to take place, and unless another system of disturbance of similar character is suddenly developed in its neighbourhood (which, as we shall see, is of common occurrence), comparative atmospheric tranquillity, with high-pressure systems, is established. Immediately previous to, and during the final process of dissipation, the Eastward progression of the depression area is commonly arrested. Thus every depression area when unimpeded

tends to undergo certain developments, which for convenience sake may be divided into three stages or periods: the *primary*, when the system is in process of formation and is of small dimensions; the *secondary*, when that formation is completed, and it occupies a more extended portion of the earth's surface; and the *tertiary*, or final, when it is in the act of breaking up, the forces to which its development is due being expended. The distance traversed by the whole system in its different stages varies exceedingly, as does also the rate of progress, and the time in which its journey is completed.

These developments are, however, frequently checked or interrupted by unfavourable atmospheric conditions. It is very common to find a depression system of limited extent destroyed or absorbed by the sudden formation or approach of a larger system of the same type. Other depressions force their way into the neighbourhood of very extensive areas of high pressure, by whose dry currents their progress is retarded, and they are themselves finally filled up and destroyed in a manner which will be described hereafter.

Primary Stage of Depression Systems.

In speaking of the commencement of any system of atmospheric circulation we must be understood as alluding to its commencement in point of time, not in any particular point of space. The distinction is important, because the later stages in the development of such a system are frequently mistaken for the earlier, and when in its progress the system enters the region of observation, observers are often tempted to imagine it as having been immediately developed within that

region, although it may in fact have already traversed many hundred miles of the earth's surface. Passing as these systems do over so considerable a portion of space, it is obvious that in most localities the opportunities of examining them in their later stages must be much more frequent than those which present themselves for the investigation of their first formation; and when first developed within a limited region of observation they often pass out of it before the revolving character of their currents, which is less discernible until their secondary stage, succeeds in attracting attention. Very numerous, *e. g.*, are the instances in which the centres of progressive depression pass over some portion of the British Isles; but the great majority of these have already traversed several hundred miles of the earth's surface, and the point of primary development of the greater number appears to lie nearly in mid-Atlantic, and altogether outside the region of regular observation. On the other hand, when the forces to which the circulation is due commence their operation in the first place over the British Isles, the system of currents is frequently not completely established until the phenomenon has passed to the Eastward, to the Baltic, Sweden, or Central Europe.

Opportunities, however, of investigating the nature of these systems of currents in their earliest stages occur from time to time in Western Europe. In the last five years from about eight to sixteen or seventeen examples have annually occurred in which the first development of well-formed depression areas has taken place within the limits of the British Isles. Of these a few only have been of sufficient intensity* to be pro-

* The term "intensity," as applied to systems of atmospheric circulation, is employed here and elsewhere in these pages as the most convenient form of

ductive of serious storms; the majority have been systems of comparatively feeble, though well-defined currents: the latter class, however, commonly proving almost as favourable subjects of investigation as the former. In Norway such developments appear to be nearly as numerous as in Britain. Spain and Portugal originate a considerable number, the Pyrenees a great many, but the latter are of small diameter and peculiar conformation, and rarely travel far. Italy seems to be the seat of development of a few, the Alpine ranges of a great many, Northern Germany of a few, and central France rarely, if at all, of any.

It is obviously of the greatest possible importance to analyze minutely the atmospheric conditions antecedent to the primary formation of these systems, whenever such formation takes place within the region of regular observation, in order to discover which of these antecedents are (if any are) invariable, and which are not; and of the latter class, which appear to be prevalent and which may fairly be reckoned as accidental. To such an analysis it has been my endeavour to subject all the most favourable of those examples which have for some years occurred. The results of the investigation may be thus briefly described.

1. No very direct connection is traceable between the formation of systems of retrograde currents and antecedent irregularities of temperature in that portion of the atmosphere in which they are produced, such

expression to denote the greatness of baric differences, in other words, of the dynamical wind-conditions, in baric areas. Thus an "intense" depression is not necessarily one in which the minimum pressure is actually very low, but in which it is very low relatively to the pressure of the neighbouring portions of the atmosphere, or in which the "gradients" "are steep"; and by an "increase of intensity" is signified augmentation, by the "diminution of intensity," the lessening, of the baric differences, *i. e.* of the proximity of the isobarics over any portion of space.

systems being found to originate in the midst of either normally or abnormally high or low temperatures.

2. They are also developed in the midst of either moderately high or low surrounding pressures, but rarely in the midst of very high or very low pressures.

3. A connection, but not of an invariable character, exists between such developments and the previous distribution of the pressure centres. Instances occur in which these systems originate in the neighbourhood of the central calms of areas of direct circulation; others, in which they are formed in the outlying currents of any of the arcs of the same, but very rarely except when the system of direct currents has existed for a considerable period. The conditions, however, most favourable to their development exist when an old and widely-expanded depression area is in its final stage, and about 70 per cent. of all the depression systems primarily developed in Western Europe are produced in the S.W. or S.S.W. arcs of such old depression systems.

4. A connection of an *almost* invariable character exists between such developments and the antecedent steepness of the barometric gradients. The systems are very rarely developed except when the atmosphere, immediately previous to the development, is comparatively tranquil and the baric differences are low, isobarics being far apart or diverging.

5. The formation of every true system of retrograde currents is *invariably* preceded, as well as accompanied, by *heavy* and *extensive* precipitation in the region where the formation takes place.

In the first of these generalizations it is not of course intended to deny what is in fact a meteorological truism, that *all* systems of atmospheric circulation are *ultimately*

dependent upon the operation of solar heat acting in conjunction with the effects of the earth's rotation. What is asserted is simply this, that neither the diminution in the tension of dry air under the influence of a rise of temperature, nor its increase under a fall of the same, constitutes the direct cause of the true progressive systems of retrograde circulation in our own regions of the globe. It happens not uncommonly in the summer months in Europe,—and the phenomenon is often well marked in seasons of exceptional drought and heat,—that a rarefaction of the atmosphere over the region where the heat is excessive establishes more or less of a *courant ascendant* over that portion of the earth's surface, with a temporary baric depression unaccompanied by precipitation. This is followed by an in-rush of air of higher tension from the cooler portions of the atmosphere, and the currents thus attracted fall in a more or less noticeable degree into the helix form, and are retrograde in direction. But these pseudo-depressions are completely distinct in character from the true progressive depressions whose peculiarities have been already described, the former being commonly stationary or nearly so, of brief duration, and seldom productive of serious atmospheric disturbances; while the latter are permanent in a remarkable degree, originate important wind-systems, and traverse the surface of the globe according to definable laws.

The fact that the true depressions are never developed except under the condition of precipitation, and that precipitation forms apparently the only invariable antecedent of their development, necessarily leads us to infer that in the abstraction of aqueous vapour from the atmosphere we have the principle of the creation of these systems. On the other hand, the fact that precipitation

in large amount frequently takes place without succeeding in developing a system of depression, and that certain baric conditions appear in a greater or less degree to favour the process of development, leads to the conclusion that the abstraction of aqueous vapour must cooperate to some extent with other circumstances in order to beget the effect ascribed to it.

We seem to have arrived at a point where some theoretical considerations may be advantageously employed for the elucidation of the subject under inquiry, before we proceed to examine actual instances of the development of depression systems.

Let us suppose a mass of atmosphere covering an area of some thousands of square miles, say that of Ireland, 32,500 sq. m., to be in an approximately inert condition as regards atmospheric currents, baric differences being unimportant in the various portions of the area, but to contain so much aqueous vapour taken up by previous evaporation from the surface of land or sea that the diminution of the tension of that vapour produced by a fall of 5° or 10° of temperature would at once precipitate from it a large quantity of rain or snow. Such a mass of atmosphere is commonly slowly traversing the earth's surface in one direction or another through the effects of the currents produced either by distant or preexisting atmospheric disturbances (a condition of both extensive and absolute uniformity of pressure, and consequently of complete atmospheric stagnation, being never attained). In this case it may arrive at length over a portion of the earth's surface whose temperature, from its geographical position, radiation from mountain ranges, &c., is sufficiently low to cause the precipitation of a large portion of the vapour. Or, again, such precipitation may, and often does, take place in cases where

the atmospheric mass described is really to all intents and purposes stationary, when temperatures which have been previously unusually raised by the prevalence of Southerly currents of former disturbances are rapidly falling upon the subsidence of those currents, and the restoration of equilibrium. We will imagine, taking by no means an unprecedented case, a mean rainfall of half an inch to take place in the space of a few hours over our surface of 32,500 miles. What may be expected to be in a general way the result upon this and the surrounding portions of the atmosphere, of the withdrawal of the prodigious body of elastic aqueous vapour represented by so great a quantity of water, it being borne in mind that the rarefaction consequent on this rainfall is equal to that which would be effected by the abstraction of nearly 1,000,000,000 cubic feet of air over each square mile?

Were it not for the influence of the earth's rotation, the diminution of tension resulting from the loss of aqueous vapour would be compensated almost as quickly as created by the currents flowing from all sides into the area of precipitation, and a very slight baric depression occurring as precipitation commenced would be followed on the restoration of equilibrium by an elevation of pressure as drier air occupied the place of the precipitated vapour. But it is the effect of the earth's rotation that the centripetal currents cannot flow freely into the attracting area, but fall into the helix form and tend to circulate around it, and in this circulation the tangential force of the atmospheric masses counteracting their attempt to restore the equilibrium, the baric depression in the central portions becomes very considerable. This effect is immediately augmented by the ascensional currents set up in the region where the pressure of the atmosphere is thus reduced, and the velocity

of the retrograde currents around the depression vortex may in this way become sufficiently great to be productive of the most violent storms.

The influence of the earth's rotation will obviously be ineffectual to produce a system of depression in cases where the precipitation though heavy is not extensive, or though extensive does not take place over a wide surface simultaneously. The baric effects of local showers, thunderstorms, &c., are commonly almost inappreciable, not so much on account of the comparatively small amount of vapour precipitated over a large surface during their transit, for it occasionally happens that in a single day of such showers the mean rainfall over a rather extended region is very great, but because these spasmodic precipitations do not operate *in conjunction* upon the whole mass of atmosphere surrounding the area of disturbance. Each local shower produces its separate effects on those portions of the atmosphere which are immediately adjacent to it, whose differences of latitude are very slight, and whose rapidity of Eastward rotation varies so little as to be productive of no appreciable results in the currents temporarily established.

The effects of precipitation as a motive force, when such precipitation takes place in an already developed atmospheric current, will be amply discussed in subsequent pages. It will also be convenient to defer for the present the problem here suggesting itself concerning the connection between the development of depression systems and the previous disposition of the pressure areas.

There is, however, one point in which some remarks may be opportunely made in the present place, *viz*. the connection between the intensity of the system of cur-

rents developed and the general temperature of the air. On examining the systems of retrograde currents developed in Western Europe in the summer and winter seasons respectively, and comparing these with an analysis of rainfall returns exhibiting the mean rainfall (so far as we have been able to approximate to its discovery) for the particular district and the particular shower in which the system was developed, we find that heavy and extensive rains in the summer season, and especially in very hot summers, originate less atmospheric agitation in the surface-winds than is produced by comparatively unimportant precipitations in colder seasons. This fact is the more remarkable because the condition of approximate baric uniformity which commonly immediately precedes the formation of retrograde systems is more frequent in the summer than in the winter months. It is not altogether accounted for by the circumstance that the summer rainfalls, usually partaking more of the electric character, are commonly more local and spasmodic than the winter falls, for even in cases where heavy summer rainfall is precipitated simultaneously from an exceedingly extensive cloud-canopy, the surface-currents established are far feebler than in a similar precipitation in winter. But in these cases currents of extreme rapidity are frequently observed to prevail at a considerable elevation, and therefore it is by no means clear that the effects of precipitation as a motive force are not as great on the precipitating portion of the atmosphere as when the gales are felt on the earth's surface. In connection with this point it is a significant fact that in high temperatures rain commonly falls from a much greater elevation than in low, and in our summer months it is not always the lowest strata of the atmosphere that

precipitate most water-vapour. Thus, from the records of gauges kept at different elevations over the same spot, it appears that while in our winter months the fall of rain averages about 20 per cent. less for the first 25 feet that we ascend, this diminution is only about 9 per cent. for a similar elevation in summer, and in times of great heat gauges at a considerable elevation often collect as much, in some instances even more, rain than those at the earth's surface. The same fact is of course indicated by hygrometric observations made during rainfall in summer and winter respectively, which prove that in hot weather (and especially in inland localities) evaporation is frequently taking place with rapidity in a stratum of atmosphere through which rain is simultaneously falling, precipitated entirely from higher regions; a phenomenon which is of rarer occurrence in the winter months.

We should expect, therefore, that in elevated temperatures the maximum of disturbing effect produced by precipitation would be transferred from the stratum of atmosphere nearest to the ground to those at a considerable distance from it, leaving the former in a comparatively tranquil condition. Thus at those times the surface of the earth is watered by the genial showers, without being subjected to the violent atmospheric currents which at such seasons would be of specially injurious effect.

CHAPTER V.

PROGRESS OF DEPRESSION SYSTEMS.

Why does not the revolving current established in the manner above described continue to occupy the same position, precipitation occurring in that region of the atmosphere in which it commenced, until, dry air having occupied the place of the precipitated vapour, atmospheric tranquillity is again restored? It is obvious, that were it not for the progress and expansion of the area of depression, the completeness of the general atmospheric circulation would be far inferior to what it actually is; and likewise that the beneficent effects of rains and showers would be greatly limited, very frequent precipitation occurring in certain spots of the earth's surface, and rainfall being actually constant in elevated mountain ranges, while unbroken drought continued in the surrounding regions. But what is the nature of the machinery by which showers of rain and the concomitant atmospheric disturbances, commencing in certain localities, are propagated over regions whose geographical and thermal conditions are not similar to those which immediately favour their devolopment?

The answer to this, as to almost every other meteorological inquiry, to be correct, can neither be altogether short nor simple, it being the principal difficulty of the science that every effect is the result of several causes, highly variable in operation, which, while acting in conjunction, have to be examined separately and in detail.

On a cursory survey of the most ordinary tracks taken by depression systems in the various regions of the globe, we observe that these bear a certain rude correspondence to the mean set or draught of the greater or more world-wide atmospheric currents, the trades, monsoons, and anti-trades. Thus, immediately to the N. and S. of the belt of equatorial variables, in the region of the Easterly trades, where pressures are constantly highest in a poleward direction, the local depression systems are found to travel Westwards, while to the N. and S. of the tropical variables, in the region of the anti-trades, where pressures are commonly lowest in a poleward direction, the depressions ordinarily traverse the earth's surface with a motion inclining to the East. This would lead us to infer that the depression systems are swept Eastwards or Westwards according to the prevalent directions of the great currents of air; just as we see, on a windy day, the whirlwinds of dust or leaves traversing a road in a direction corresponding with that of the wind-draught at the time, or as the eddies in a stream of water follow the general course of the stream, irrespectively of the direction of their own axial rotation.

But when from such a general survey we pass to a detailed examination of the tracks of individual depression systems in the temperate regions of the globe, we are confronted with a class of facts which show the inadequacy of the solution above suggested to account for all the phenomena observed. In the first place the rapidity of the progress of depression systems is frequently enormously in excess of that of the general flow of the surrounding currents. Thus, instances occur in which systems of depression traverse in three days the whole of Europe, from the W. coast of Ireland to

Northern Russia or the Black Sea; while, except in the actual currents developed by the depressions themselves, the general motion of the atmosphere is extremely slow, and inadequate to transfer the body of circulating atmosphere in the same period over a distance of one-fifth or one-tenth part of that actually traversed. Further, while the depression systems are advancing with this extreme velocity of progression, the nodes of high pressure with their direct currents are frequently travelling with an extremely slow and variable motion, or are stationary, or even temporarily progress from E. to W. Again, in "polar periods," *i. e.* at those seasons when the ordinary distribution of the general pressure conditions is reversed, and pressures are elevated over the extreme North of the Atlantic and of the Continent of Europe and depressed in the South, and the general set of the currents is consequently from E. to W., we still commonly find local depressions to be propagated from W. to E., their progress being indeed retarded, but its direction not being reversed, by the alteration in the general flow of the atmosphere.

Lastly, we are unable to account for the Eastward progression of the baric depressions by attributing it to prevailing Westerly upper-currents, since in several instances depressions have been found to travel Eastwards with remarkable rapidity when observations on the motions of elevated clouds, made simultaneously at different quarters in the neighbourhood of the depression, have demonstrated the existence of extensive upper-currents at the time from *Easterly* points.

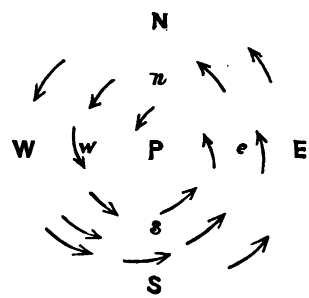
In short, each system of depression, directly it is created, appears to travel in a direction inclining to the E., with a kind of self-developed motion, independent to a certain extent of the motion of the adjacent

portions of the atmosphere. What is the principle of this progression, and to what laws are its variations reducible?

It is Precipitation which, as we saw, plays the most important part in the primary development of each baric depression. The same process taking place in already developed currents is the principal agent in producing their change of geographical position.

The little diagram below will serve to illustrate the process of Eastward progression which results from the development of an area of depression. The point P represents the region in which heavy precipitation has been taking place, and the circulating arrows the atmospheric currents drawn in a helix towards this region. Now it is obvious that the currents attracted from higher latitudes, and travelling from N. to W., undergo in their course a process of elevation of temperature. Having been exposed to a comparatively small number of the solar rays, they arrive at a region in which they are subjected to a greater number, and pass over a portion of the earth's surface which is comparatively heated. Their capacity for aqueous vapour is therefore undergoing augmentation, and very little or no precipitation accordingly takes place in these currents. A similar remark applies to the same currents in their motion from W. towards S. and to the currents drawn from W. with which in their course they become combined. Very little rainfall then occurs in the N.W. and S.W. arcs of the circulation. But the currents which are drawn from points

FIG. 3.



S. of the area of precipitation undergo a process the converse of those which blow in from the N. As they pass from S. towards E. their temperature, and consequently their capacity for holding aqueous vapour, is lowered, and a portion of their vapour precipitated. Thus the precipitation commencing at the point P is constantly *propagated in an Eastward direction.* The loss of aqueous vapour in the East begins in its turn to attract fresh currents, which, in accordance with the universal conditions of the earth's rotation, tend to circulate in the same retrograde direction as the former, and in the course of a few hours from the original development of the circulation the whole system occupies a position considerably to the East of the locality in which it was developed.

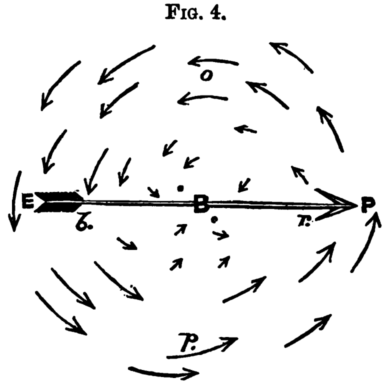
In the Southern hemisphere precipitation tends to produce an Eastward progression of the baric depressions in a precisely similar manner. There it is the Northerly currents which are commonly the precipitating, and the Southerly which are the evaporating winds; but as the atmospheric circulation around baric depressions is in the Southern hemisphere direct instead of retrograde, the precipitating currents occupy, as in the Northern hemisphere, a position to the Eastward of the baric minima.

The very common expansion of the area, due partly to the tangential force of the masses of circulating atmosphere, is also greatly promoted by the same conditions as those which necessitate its Eastward transference. The currents drawn from *s.* to *e.* (Fig. 3), passing over a more limited portion of space than those which travel from S. to E., undergo proportionately a less diminution of temperature, and the aqueous vapour which they precipitate is consequently

less in amount. The latter currents having a curve of larger radius, and coming from much warmer latitudes, precipitate a greater rainfall in the East, and this in its turn attracting currents from still more distant regions, the whole area is progressively enlarged.

On the commencement of precipitation in the first formation of the system we saw that a decrease of pressure resulted. This decrease commonly continues throughout the further development of the system. What was therefore in its primary stage a limited area of precipitation and slight baric depression, frequently becomes in the course of its secondary stage a very widely expanded area of very low pressure, in the Eastern portion of which precipitation steadily continues, while in the centre and nearer to the Western arc rainfall ceases entirely, or only occurs in spasmodic and local showers. Calms or light variable breezes prevail throughout this region, which are succeeded in each locality over which the depression passes by the fresh polar breezes of the Western arc of the circulation. There are frequently clear skies (the "*trennende helle*" of Dove) in the neighbourhood of the centre, and beneath these evaporation takes place to a considerable extent, but is usually most rapid under the dry breezes of the Western arc which succeed the calm. The point of greatest baric depression, represented in Fig. 4 by the

FIG. 4.



letter B, thus constantly follows in the rear of the region of heaviest precipitation P, and is itself followed by the tract of greatest evaporation E.

The contents of this and the preceding chapter may be thus briefly recapitulated.

I. Extensive precipitation occurring in a region of atmosphere previously approaching a condition of tranquillity, is the primary factor of every system of baric depression, with its resulting atmospheric circulation, retrograde in the Northern and direct in the Southern hemispheres.

II. Such an atmospheric circulation being established, the changes in their capacity for aqueous vapour which its currents undergo in consequence of the unequal distribution of solar heat, tend to propagate the depression in an Eastward direction.

It must be here remarked that while this tendency of precipitation to promote the Eastward development of local depressions is totally dissimilar in its *mode of operation* to the mechanical influence of the system of the anti-trades, or prevailing Westerly currents of the temperate zones, it yet most commonly coincides with the latter in *direction*. In other words, while the influence of precipitation resulting from the mean distribution of solar heat in extra-tropical latitudes tends to propagate the local depressions in an Eastward direction, the prevailing distribution of atmospheric pressures in those latitudes does also commonly tend to sweep the depressions in the same direction by virtue of a mechanical

impetus. It is necessary to defer the consideration of the manner in which the latter or baric condition influences the atmospheric progression to that portion of this treatise in which the general relative distribution of high and low pressure areas, and their mutual influence upon each other, will be described. Meanwhile, bearing in mind that the baric condition is one of a highly variable character, and that its occasional reversal does not succeed in reversing the direction taken by the local depressions, we proceed to consider more closely the law of precipitation, which is the most important factor of the atmospheric progression in our own regions of the globe, and on which the European wind-systems in a very great measure depend.

CHAPTER VI.

VARIATION OF THE PROGRESSION.

I AM conscious that it will be objected to the account hitherto given of the influence of precipitation as a disturbing force, that it appears to exemplify that theoretic and *a priori* method of reasoning which is so inapplicable to meteorology. But although we have hurried onwards in the endeavour to give a succinct general account of the influence of precipitation, every successive step in the account has been founded on prolonged empirical research. In the attempt to weigh in the balance the atmospheric currents which day after day through successive years have passed over Western Europe, it has been especially my endeavour to obtain all available reports of the amount of precipitation occurring in the various localities traversed by the different segments of areas of depression; to combine and compare these in order approximately to discover the mean rainfall of each region during the passage of the depression, and to estimate, with such mathematical precision as the subject admitted of, the actual baric effects produced by the precipitation upon the surrounding portions of the atmosphere. The rules already laid down respecting the connection of precipitation with the atmospheric circulation have been established to my own conviction by these investigations. To the reader, in a science whose subject-

matter is of so complex and variable a nature, the description of some actual examples, though far from furnishing a logical proof of the accuracy of any generalization, will convey more conviction than would be furnished by statistical tables of any length, and a considerable portion of this Part will accordingly be devoted to the description of instances of the formation and passage of depression areas. But without a rather more clear apprehension of the general laws of precipitation, the instances themselves will fail both of instructiveness and interest in the points which they most completely tend to establish.

We have hitherto alluded to the distribution of temperature upon the earth's surface as though it were dependent upon differences of latitude only. The globe over which our theoretical baric depressions have been conceived to progress has been in effect one whose surface is both homogeneous and uniform, and whose climatic differences result solely from the varying incidence of the solar rays. To such the conditions of the actual globe are in the highest degree dissimilar. The division into oceanic and land surfaces,—broad in theory as it is, but infinitely intricate in actual outline,—surfaces so exceedingly diverse in their powers of absorbing, conducting, and radiating heat, exercises in several ways a prodigious influence on the motions of the atmosphere. Then again, the character of each of those surfaces themselves presents conditions of endless variety, the land being scarcely more diversified by arid plains, extensive marshes, lakes, rivers, vapour-condensing mountains, than is the sea by its interchange of cold and warm currents: the former carrying the low temperatures and the icebergs of the polar regions into the neighbourhood of the tropics;

the latter bearing into very high latitudes the heated waves of the torrid zone.

The unequal distribution of heat over the earth's surface is creative of atmospheric agitation both directly and indirectly. Heat and cold produce currents of air directly by their effects upon the tension of the atmosphere itself, indirectly through their effects upon the tension of the aqueous vapour suspended in it. We might naturally expect that over the whole surface of the globe the former influence would operate so much the most potently of the two as altogether to mask the effects produced by the latter. But as a matter of fact we find that while in the more heated regions the principal air-currents are chiefly due to the immediate action of heat in conjunction with the effects of the earth's rotation, the farther we advance towards high latitudes the less distinctly traceable is this direct influence of heat, becoming more and more interfered with by the indirect or vapour influence. Through their comparative neglect of the latter, meteorologists, while dealing successfully with the problems of the more constant and extensive winds of tropical latitudes, have met with repeated failure in their treatment of those which are presented by the variables of the temperate and polar regions. The greater complexity of the wind-phenomena of the higher latitudes is to be attributed in great measure to the relatively greater effects of the influence of aqueous vapour. The changes of state undergone by the water which the atmosphere takes up, retains, and precipitates, play a most important part in the production and propagation of the atmospheric currents. And these changes, so spasmodic and irregular in character, are themselves dependent upon the local influences of the nature and elevation of the earth's

surface. Is it possible to trace order amid the apparent chaos which these variable phenomena exhibit? A step will have been taken in this direction if we can succeed in discovering a connection between the progress of baric depressions and the varying thermal conditions of the surfaces over which they advance.

Some allusion has been already made to our system of comparing and combining the tracks of baric minima with the view of obtaining the "mean lines of atmospheric progression," and it has been remarked that these lines exhibit both seasonal and geographical variations. In other words, the direction likely to be followed by each centre of baric depression, which appears in any locality, is dependent both on the season of the year at which it exists, and on the geographical position which it occupies at the commencement of its career. An example may render this observation clearer. In the little Table below are classified the tracks of all the well-marked progressive baric depressions whose central portions have appeared upon the S.W. coast of Ireland in the months of February and July respectively, from the year 1860 to the year 1870 (both inclusive).

Month.	Total Number.	Between N.W. and N.	Between N. and N.E.	Between N.E. and E.	Between E. and S.E.
February .	24	1	3	10	10
July ..	26	3	17	5	1

This gives a mean direction of nearly E. by N. for February, and of nearly N.N.E. for July; and it appears that a baric depression, whose centre exists on the S.W. coast of Ireland in the month of February, may be ordinarily expected to progress across the British

Isles towards the German Ocean, but that a similar depression in the month of July will probably take a more northerly course in the direction of the N.W. coast of Scotland.

But the seasonal lines of progression are not geographically parallel. That is to say, although the baric minima which chance to exist over the S.W. coast of Ireland in February and July may be expected to travel to E. by N. and N.N.E. respectively, it by no means follows that minima developed in those months over *other* regions of Europe, or of the North Atlantic, may be expected to take a similar direction. On the contrary, the tracks of those minima which have been found in February on the West coast of Norway have been in a large percentage of examples towards S.E., from the Gulf of Bothnia to E.N.E., from Northern Germany to S.S.E., from the Gulf of Lyons to N.E., while examination seems to prove that minima existing in the latitude of Ireland, but between the longitudes of 20° and 40° W., travel in a majority of instances to N.N.E. In July again, the Norwegian depressions follow a mean direction to N.N.E., those in Central Europe to N. and N.N.W., while evidence goes to show that on the Atlantic surface to the immediate West of the Irish coast the depressions travel to N.E.

The three succeeding charts exhibit the *mean* tracks of baric minima in Europe in the months of March, August, and December.

In these charts the direction of the arrows is intended to show the mean direction taken by the centres of depression systems, their length the mean distance traversed in a period of twenty-four hours, and their relative number in each geographical space the relative

frequency of the occurrence of depression centres in that space.

Before proceeding to call attention to some of the points which these tend to elucidate, it is necessary to premise that in respect of accuracy the lines upon which the greatest dependence can be placed are those which traverse portions of the British Isles and of France, the data for examining the course of such depressions being most satisfactory, and most easily and abundantly obtained, while those of Central Europe have been drawn from an examination of fewer instances. The lines traced upon the Atlantic surface are the least satisfactory, not merely on account of the comparatively scanty and casual character of the returns, but from the great complexity introduced into all the investigations by the motion of the reporting vessels, allowance having always to be made for the alteration in the geographical position of the latter, as they meet, follow, pass, or are passed by the various systems of atmospheric circulation. Oceanic anemology, rendered by the peculiar difficulties attending these calculations almost a separate branch of the science, has hitherto been productive of few results, but those highly significant. Especially does the fact appear to have been established that the tracks of baric depressions upon the surface of the ocean are more regular and parallel, and that the rapidity of their progress is more uniform than is the case with depressions which traverse continental surfaces.

We now proceed to consider the two principal facts, or classes of facts, most prominently illustrated by the charts, which are these.

I. The mean tracks of depression centres trend greatly to S.E. across Western Europe in the colder months, and towards N.N.E. in the warmer.

II. The mean tracks show a peculiar convergence towards certain districts of Europe, *viz.* the Alpine ranges, the Pyrenees, the Northern portion of the British Isles, and Scandinavia.

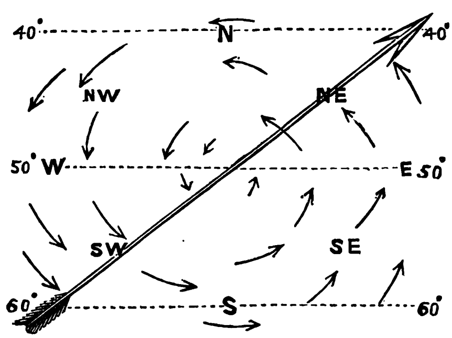
For the sake of clearness we shall, according to the mode of procedure previously adopted, investigate separately these two points, portions though they are of a single general law.

I. In the account already given of the influence of precipitation in promoting the advance of depressions, we saw that temperature being commonly lower the farther we retire from the tropics towards the poles, the Eastern portion of a low-pressure circulation will, in a general way, tend to precipitate the largest quantity of vapour. The actual operation of this law now requires to be more minutely described.

Every current of air passing over unequally heated portions of the earth's surface tends to equalize their temperature. Itself becoming, approximately, of the temperature of the surface which it traverses, it tends to transfer that thermal condition to the new surface which it subsequently traverses. In the little diagram, Fig. 5, the mean isothermal lines 40°, 50°, and 60° are supposed to lie West and East (or to be parallel with lines of latitude). The arrows represent the currents of an imaginary retrograde circulation around a region of baric depression. Now, the Northerly wind at W. and the N. Westerly at S.W. are, as described in a previous chapter, undergoing augmentation of temperature, and of capacity for aqueous vapour. They are evaporating currents. Being of lower temperature than the surfaces which they traverse, they are felt as cold winds, but as they proceed they acquire some of the heat of those surfaces, while themselves depressing the tempe-

rature of the latter. The Westerly wind at S. partakes of the same character in a less degree, and is felt as a cool current though flowing *along* an isothermal line, since it (or rather a portion of it) has previously travelled from colder regions. The current does not in fact attain its own actual maximum of temperature till it has passed S. and arrived nearly at S.E. From this point to N. it is felt as a warm and damp wind; its temperature is higher than that of the surfaces over which it passes; and its power of retention of the aqueous vapour which it has previously taken up is undergoing diminution. It is in consequence a precipitating current; but its most rapid depression of tempe-

Fig. 5.



rature is not found to be actually at E. where it cuts the isothermal at right angles, but to the Northward of that point, and between E. and N.E., which is consequently the region of greatest precipitation.

The Easterly wind at N. still has a temperature slightly in excess of that of the surface which it traverses, and is felt as a precipitating current, though in a less degree, travelling as it does *along* an isothermal; but the N. Easterly current at N.W. begins to be experienced as a cold and dry wind, is undergoing an aug-

E

mentation of temperature, and of capacity for water-vapour.

Thus, with mean isothermals parallel with lines of latitude the tendency of an area of baric depression will be to precipitate most in its N.E. or E.N.E., and to evaporate most in its W.S.W. or S.W., and the track of its development will consequently be towards N.E. or E.N.E.

A considerable cluster of facts are connected with this inference, to one or two of which we shall allude here, as they serve to illustrate and strengthen our position, although a more minute examination of them must be deferred for the present.

Thus, in accordance with what has been said we should expect to find that on an oceanic or uniform continental surface, with mean isothermals lying West and East, or thereabouts, the heaviest rainfall will commonly be in S. Easterly currents, and that these will be succeeded by the greatest baric depression, and subsequently by currents from N. West. And this is usually found to be actually the case.

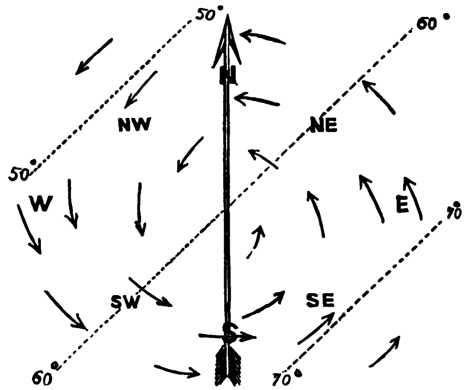
Again, under similar conditions, since the currents of air will rush with greatest impetus into the region where precipitation is heaviest, we might expect (apart from all considerations of the general distribution of atmospheric pressures in the region of the Anti-trades) that the S. Westerly currents or those blowing immediately into the heaviest rain would commonly be the strongest, and for a similar reason the East and N. East the weakest winds around each centre of depression. The alteration in the tension of the dry air might be expected to promote the same result, a body of atmosphere transferred from an isothermal of 60° to one of 50°, contracting to the extent of about $\frac{1}{49}$th of

its previous bulk, and a body of atmosphere passing from the temperature of 50° to that of 60° expanding in the same degree. But in those instances in which isothermals are parallel with lines of latitude, the contraction of the equatorial current and the expansion of the polar due to these influences are mechanically compensated; the equatorial current, which is flowing *between converging meridians*, is undergoing *compression*; and the polar current, whose course is *between diverging meridians*, is undergoing *expansion*. We are not therefore surprised to find that upon an oceanic surface, with a baric depression taking a N.E. direction, there is no great difference traceable in the average strength of the Southerly winds in its Eastern arc and the Northerlies of its Western, while the West winds of its Southern portion are commonly more violent than the Easterlies of its Northern.

To return from this digression on the currents of depressions to the laws which regulate the course of the depressions themselves. In all regions of the globe, and more especially upon the coast of every continent, isothermals frequently deviate vastly from an exact parallelism with lines of latitude, on account of the very unequal effects of solar heat upon land and sea surfaces. In Western Europe in the summer season the mean temperature of the land surface frequently becomes many degrees higher than that of the neighbouring oceanic surface. The air over Central France, Germany, and Denmark becomes hotter than that over the Bay of Biscay, the English Channel, and the German Ocean respectively. Fig. 6 will serve to illustrate the result of such thermal conditions upon the progress of a baric depression. Here the inclination of the isothermals is from S.W. to N.E. Con-

sequently the N. East is no longer the current of minimum temperature, but the N. West; and the

Fig. 6.



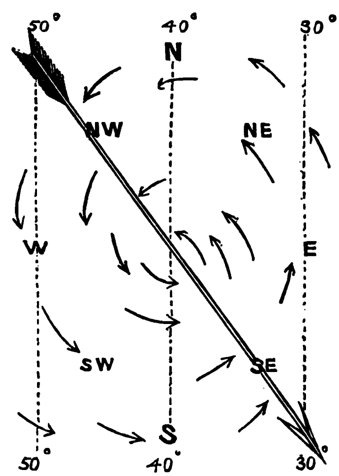
S. West wind is no longer that of maximum temperature, but the S. East. The Easterly current now undergoes the *most rapid diminution* of temperature, instead of the Southerly, and therefore precipitates in largest amount. The result is, that the depression, with its system of circulating currents, is developed towards the North.

In accordance again with these conditions we should be led to anticipate that at the season of the year when they prevail, rainfalls will be greater with Easterly than with Southerly winds, and that the greatest decrease of pressure will attend the Easterly currents, and the greatest increase the Westerly currents of each area of depression; and this is precisely what we find to be the case.

In the winter season the relative distribution of mean temperatures upon the continental and oceanic surfaces is commonly reversed. The air over Continental Europe becomes very much colder than that over the Atlantic in the immediate West, and mean isothermals

commonly have an inclination from N.W. to S.E. They sometimes even lie N. and S., as represented in Fig. 7, where the highest temperature is in the West, and the lowest in the East. In this instance, currents at S.E. (S. West winds) will be those whose temperature undergoes the most rapid diminution, and in these the aqueous vapour will consequently be precipitated in greatest amount. The area of baric depression will therefore trend to S.E.

Fig. 7.



Accordingly, in the winter season of Western Europe the rainy winds are, generally speaking, the S.S.W., S.W. or W.S.W., and the greatest barometric falls commonly attend the passage of a belt of these winds.

II. If we had simply to deal with an oceanic surface and a land surface of uniform character and elevation, the problems under investigation would be of comparatively simple character, and the tracks of baric depressions, while subject, in the neighbourhood of the land, to the seasonal changes, would both be more rarely deviated from, and would be far more direct and parallel than they actually are. The aqueous vapour of which the ocean is at all times the principal source would then be precipitated in the winter months chiefly upon the coast line and its neighbourhood. Baric depressions would rarely be found to penetrate far into the interior of extensive continents, becoming dissipated through the

absence of the disturbing influences shortly after having left the vicinity of the sea. In the summer season extensive precipitation would rarely take place upon the coast, and the rainfall of inland localities would be confined to local and electric showers. The changes in the tension of the dry air effected by the increase or diminution of solar heat would produce over the coast line in the summer months, even in cool climates, regular atmospheric currents, similar in character (though feebler in force) to the land and sea breezes which actually prevail in the hotter portions of the globe.

But in hilly and mountainous districts we have a class of influences which interfere to a gigantic extent with the circulation above described. These operate upon the atmospheric currents both by mechanically arresting and diverting the motion of the air, and by the enormous changes in tension which their cold surfaces produce. To the latter effect, or that directly produced upon the baric areas, we shall at present confine our attention.

Each range of elevated mountains acts upon the atmospheric circulation precisely as a polar region in miniature, diverting and attracting the baric minima whose circulating currents chance to come into contact with its surface. It is easy to obtain from theoretical considerations a general idea of the nature of this attracting influence. Referring back to Figs. 5, 6, and 7, we can readily perceive that the advance of an area of depression would be arrested, and its direction altered, by the contact of any of its circulating currents with the very cold surface of a mountain range not lying in the direct path of the actual baric minimum. Thus, where the advance of depressions over a uniform surface would be towards N.E., the existence of lofty hills in the S.E. will arrest the N. Eastward development of the minimum,

and cause it to trend towards S.E. For the S. Westerly currents in the S.E. will now precipitate the greatest amount of aqueous vapour, the South and S. East winds to the Northward of the mountains becoming of a comparatively dry character. Again, the existence of a range of hills in the North will similarly cause the area to travel to the North instead of the N. East, for the S. Easterly winds, though precipitators, will not in this instance precipitate as much as the Easterly currents, whose temperature is reduced in a very much greater degree.

Similarly, in cases where depression areas trend, on account of the general distribution of temperature at the season, towards S.E., the existence of high lands in the N.E. may cause the S. Easterly winds to precipitate more than the S. Westerlies, and the progression of the area will become N.E. On the other hand a range of mountains in the S.W. of an area of depression will cause the N. Westerly winds in that region to precipitate in largest amount, the S. Westerly winds in the S.E. becoming proportionately dry and evaporating currents. Consequently the area will tend to expand towards S.W.

The ultimate direction taken by the minimum, and the question whether or not the minimum will actually traverse the range of interfering mountains, is dependent on the nature of the surfaces lying upon the farther side of that range. If these latter are such as to promote in a high degree the process of precipitation, the baric minimum will advance towards them. If, on the other hand, they are such as to arrest precipitation, the minimum will tend to remain stationary in the rear of the range of mountains, either until it is dissipated through a diminution of precipitation, or until the expansion of the area becomes so great that the currents

of one of its distant arcs come in contact with another precipitating surface, when the minimum will begin to travel off in that direction.

It appears certain that the convergence of the mean tracks of depression centres towards the mountainous districts of Europe is due to the principle above described. Thus, the reason why an area of depression, which has travelled from the South of Ireland across the English Midlands should so frequently, on reaching Belgium and Northern Germany, suddenly trend to the South, would appear to be that the W. and S.W. currents in its S. and S.E. portions suddenly lose their aqueous vapour by precipitation upon the Alpine ranges; the Southerly currents in Prussia and Denmark becoming in such a case of a comparatively dry character, and the diminution of pressure being greatest in Switzerland and Bavaria. Another area of depression advancing Eastwards along the Channel will for a similar reason be diverted towards E.S.E., while an area existing in Northern Italy may simultaneously even travel Northwards, the water evaporated from the Mediterranean and Adriatic surfaces being precipitated upon the Alpine ranges in its extreme North.

The high lands of Northern Britain exercise a somewhat similar influence. Numerous depressions, which previously to the contact of their currents with these precipitating surfaces have been traversing the N. Atlantic towards N.E., are diverted Eastwards when their Southerly and S. Westerly currents come in contact with the Irish, Scotch, and Cumberland hills, precipitation becoming greatest in their S.E. and E., and being arrested in their N.E. portions. Again, depressions advancing N. Eastwards towards the entrance of the English Channel frequently have their course diverted

towards North, precipitation becoming greater in their Easterly than in their S. Easterly currents.

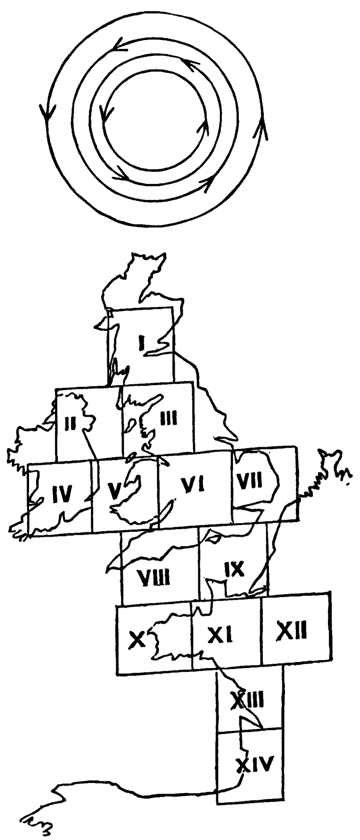
Again, it is not surprising that depressions which exist to the immediate East of Scotland in the winter months should frequently *temporarily* expand towards S.W., the N. and N.W. currents which have taken up a certain amount of vapour in the Northern seas precipitating this as snow and hail upon the high lands of Northern Britain. Yet the *eventual* progress of this important class of depressions is invariably towards E. or S.E., because the N. Westerly winds never precipitate very extensively upon our warm S. Western coast, while the West winds simultaneously prevailing in Northern Germany precipitate in great amount.

It is in the highest degree probable that in the course of a few years great light will be thrown upon the whole subject of the effects of mountain ranges on the baric conditions of the atmosphere by observations carried on in elevated situations, such as the researches which Professor Mohn is pursuing in Norway, such investigations being likely to detect the processes of which we now know only a few general effects.

The influence of rainy regions, such as elevated coast lines, and, still more, mountainous districts, in *detaining* baric depressions, though frequently traceable in a highly interesting degree in the history of individual depressions, is exceedingly difficult to exhibit in any tabular and statistical form, because depressions not only differ in the direction of their course according to periodic antecedent conditions of the atmosphere, but vary indefinitely in their dimensions, intensity, and in the stage of development in which they reach each dis-

trict of observation, and all these elements affect the result in every individual case. It does not, nevertheless, appear a hopeless task to trace in the mean of a large number of depressions the detentive influence of rainy regions. If the results of the following scheme are hitherto of a meagre character, applied as it has been from necessity to a small area, and extended over the very limited period of four years, the system itself is such as to promise valuable conclusions when more largely developed.

Fig. 8.



In the accompanying chart, portions of the British Isles and Western France are divided into numbered squares. Column A of the subjoined Table gives the total number of instances in which centres of depression occurred in each of these squares, from Nov. 1, 1866, to Nov. 1, 1870; column B, the number of instances in which a centre of depression remained for upwards of twenty-four hours within the same square; column C, the resulting percentages, or the frequency of a delay of upwards of twenty-four hours, relative to the number of depression centres occurring in each square.

No.	A.	B.	C.	No.	A.	B.	C.
I.	64	9	14	VIII.	17	2	12
II.	49	12	24	IX.	18	1	7
III.	30	5	17	X.	16	2	13
IV.	35	4	11	XI.	12	0	—
V.	26	1	4	XII.	20	0	—
VI.	13	0	—	XIII.	20	4	20
VII.	26	0	—	XIV.	42	15	36

For some inquiry into the relative frequency of areas of depression in the different regions, we must refer the reader to a later portion of this treatise, in which the predominant distribution of the pressure centres and the general character of the atmospheric circulation in Western Europe will be considered. Our remarks will be at present confined principally to the figures in the right-hand columns, and we shall offer some observations (drawn mostly from an examination of the instances enumerated in the Table) descriptive of the character of the depressions in the principal regions. By drawing in imagination concentric circles, similar to those figured upon the opposite page, around each region successively, the baric influences of the various surfaces over which the retrograde currents circulate will be rendered clear to the apprehension.

It will be best to commence with those regions whose percentages are the highest, and whose tendency to detain the baric minima appears consequently to be the greatest.

No. XIV. With a baric minimum situated within this square, we find Northerly and N. Westerly currents in the Bay of Biscay, Westerly and S. Westerly in the

Peninsula, while Easterly winds are blowing over Northern and N. Western France and the English Channel. The first-named currents are invariably of a dry character, and are engaged in absorbing a large quantity of water from the oceanic surface. On the Northern coast of Spain, from Corunna to Bilbao, these are felt as squally winds (similar in character to the corresponding N. Westerlies often experienced on the Western coasts of the British Isles), nearly rainless in summer, and precipitating only in spasmodic hail, snow, or rain showers in winter. As these draw to the N. East of the Peninsula as S. Westerly and Westerly currents, they part with the vapour absorbed from the Channel and Bay of Biscay in copious precipitation upon the cold Pyrennean ranges. The area of depression tends accordingly to develop itself towards S. East, the minimum pressure following as usual in the wake of the greatest precipitation.

There exists, however, immediately beyond the Pyrennean range, a region comparatively unfavourable to precipitation, and the S. Westerly winds felt at a greater radius from the centre of depression, along the Eastern coast of the Peninsula from Alicante to Barcelona, are of a somewhat dry and evaporating type. Accordingly a considerable proportion of these systems hang over the Pyrenees until dissipated, a process which in a rainy region sometimes occupies several days.

The fate of the survivors appears to depend on the season of the year at which they exist. In the summer, and particularly in July, August, and the early part of September, several of the Pyrennean depressions, which are at this season commonly of small extent, have been observed to travel at first towards N.E., heavy electric rains being experienced in the direction of Central France; then to N., and gradually even to

N.W., into squares XII. and IX., invariably diminishing in intensity as they advance, though increasing in extent, until dissipated. In no instance have these been traced farther north than lat. 53°.

In the winter months, when depressions of more important dimensions often reach the region of the Pyrenees from the Atlantic, the resulting circulation is such that the Southerly or S. Westerly currents are experienced over a large extent of the Western Mediterranean. These part with their aqueous vapour in heavy precipitation accompanied with rapid barometric fall in Italy. The whole depression appears to take a sudden leap in an Eastward direction, the minimum is experienced either in Southern or Northern Italy, while pressures recover briskly in the Bay of Biscay and the Peninsula; the whole system of currents undergoes a change, and the mistral suddenly sweeps over the Southern coasts of France.

No. II.—Next to the Pyrennean depressions, those whose central portions are situated in the North of Ireland appear to meet with the greatest detention in their progress, nearly one out of every four which find their way into this region remaining there for more than twenty-four hours. There is a slight analogy traceable between this district and that of the angle of the Bay of Biscay. Each has an oceanic surface on the North West, and a range of high lands adapted for precipitation on the East. With a baric minimum situated in the N.E. of Ireland, Easterly winds will be experienced in Scotland, N. and N.W. upon the West coast of Ireland, drawing to S.W. in St. George's Channel. The aqueous vapour which these absorb from the surface of the sea is precipitated only in local and electric showers upon the Irish coast; but in North Wales,

Lancashire, and Cumberland, the Atlantic winds part with their moisture in large amount. At a greater radius from the centre of depression, in the Eastern and South-Eastern counties of England, in Northern France, Belgium, and Holland, the equatorial currents, meeting with less elevated surfaces, precipitate comparatively little, and accordingly the Eastward progress of the depression area is promoted in an inferior degree. Depressions whose centres are thus located are however frequently of very large dimensions, and the currents which they originate are sufficiently extensive to reach the Norwegian high lands, or the cold regions of the Polar seas, where the loss of pressure presently begins to be felt. Accordingly most of the depression centres in No. II. find their way to N. or N.E., the minimum crossing Scotland, on whose Western coasts the N. Westerly currents now begin to be felt. A certain number however, especially at those periods when the temperature of Continental Europe has been greatly depressed, have been noticed to travel first to due E. and then towards S.E., through the Districts III. and VII., and have eventually found their way into Belgium and Holland, their track being marked with a heavy deposit of snow or rain. Instances of depressions travelling from the N. of Ireland directly to S.E. appear to be comparatively uncommon, and no case has been noticed in which their course was due S.

Examples in which the centre of depression is delayed for upwards of twenty-four hours in District III. have been less common, although this comprises the rainiest region in the British Isles. It must be borne in mind that the baric minimum in an advancing depression always lies in the rear of the greatest precipitation; consequently when the high lands of the North of England are most

vigorously condensing the water-vapour, the minimum is commonly experienced on the Western side of the Irish Sea. When the central calm actually arrives over the watershed, precipitation is there comparatively arrested, and the system of currents is either dissipated or advances in the direction of some new condensing surface.

No. I.—Scotland, though lying in the track (during the autumn and winter months) of a far greater number of depressions than any other portion of the British Isles, seems to detain few as compared with the North of Ireland. Of the nine stationary depressions noticed during the period of four years, it may be remarked that four were in the month of September, and these were in each case the centres of very widely expanded systems, apparently old cyclones which had traversed a considerable tract of the Atlantic; the arrest of whose Northward progress may have some connection with the fact that the water-vapour is commonly but little determined towards the extreme North at this period of the year, a dry atmosphere frequently prevailing over the Northern seas as compared with the ocean on the S.W. of the British Isles.

Of the depressions traversing this district nearly half came out of No. II.; the remainder, principally winter depressions, arrived in most cases from N.W. and N.N.W. Their subsequent fate was very diverse. The summer depressions mostly passed to N.E., N., or N.W.; but in autumn, winter, and spring, a very considerable number, after progressing a little to the Eastward into the North Sea, suddenly trended to S.S.E., not unfrequently passing through a portion of District VII., their further progress being in some cases through Holland and Northern Germany to the Baltic,

in others through Belgium and France to the Alps, Northern Italy, and the Adriatic. It was remarked that during the progress of these depressions down our East coast, heavy rainfall occurred along that coast, with winds veering from W.S.W. by N.W. to N. and N.E., and that this, the precipitation of water absorbed from the North Sea, never spread very far towards the S.W. Some of this class of depressions are productive of storms of as formidable a type as any that visit our regions of the globe.

No. IV.—With depression centres located in this square, Northerly winds will be experienced on the W. coast of Ireland, drawing to W. at the entrance of St. George's Channel, while the Easterly current will be felt at Holyhead, Armagh, and Greencastle.

On a first inspection the behaviour of the very important class of depressions whose centres occupy this district appears subject to scarcely any definable rule, but on a closer examination the operation of the law of precipitation is traceable in a highly interesting manner. In periods when the temperature of Continental Europe and of the S. Eastern portion of Great Britain is high as compared with that of the N. Western shores of the British Isles, a rather considerable number of depression systems have collapsed or become dissipated in this district; the remainder have, I believe without exception, travelled polewards into Districts II. or III., heavy rainfall accompanying their advance in North Britain. On the other hand, when the temperature of Continental Europe has been relatively low, these depressions have in most instances found their way to the Continent, but the actual track followed by them appears to depend upon the *extent* of the atmospheric circulation. Circulations of small diameter, such

as those primarily developed in the South of Ireland, commonly progress nearly to the due E., across Wales and the English Midlands, through Nos. V., VI., and VII. On the other hand depressions of very large dimensions whose centres have been located in this region have most commonly trended immediately to S.E. or E.S.E. in the direction of the West coasts of France. The reason of this would appear to be that in the case of a small area in the South of Ireland, the Welsh coast offers the first condensing surface to the Atlantic winds, while in the case of a very large area the S. Westerly currents felt upon the West coast of France precipitate in largest amount, while the rainfall North of lat. 50° becomes comparatively slight.

Nos. VIII. and X.—With a minimum situated in the former of these districts the polar current will be experienced in St. George's Channel, while W. and S.W. winds are blowing at Brest, L'Orient, and Cherbourg, drawing to S. at Portsmouth, and S.E. in the English Midlands.

With a baric minimum located in District X. the Easterly current will be felt as far South as Falmouth and Plymouth, and the S.W. wind not farther to the N. than L'Orient.

In the summer months the course of these depressions is usually Northwards, first to Scotland, and subsequently N. Eastwards in the direction of the West coast of Norway. At other seasons of the year their course is more commonly S. Eastward; in some cases through Central France towards Switzerland; in others, down the W. coast of France towards the Pyrenees.

No. VI.—Areas of depression exhibit a marked repugnance to traversing the central portion of Great Britain. In the four years selected a baric minimum

passed over this district on thirteen occasions only. The Atlantic depressions commonly pass on the N.W. of this region, being attracted to the high lands of Northern Britain; others, as we have seen, pass on the S.W. from the entrance of St. George's Channel to the French coasts. Four instances of summer depressions occurred which passed from the Channel in a poleward direction across the English Midlands. One or two gigantic depressions from the Atlantic traversed the same region in winter from W.N.W. Most of the remaining depressions were such as had been primarily developed in the neighbourhood of the South of Ireland, and were therefore of small dimensions but of considerable intensity. No instance occurred in which a depression remained stationary within this district.

No. VII.—It appears more singular that no stationary centres of depression have been observed to occur over the East coast of England, receiving as this district does a considerable number of depressions from the North of Great Britain as well as some of those from the South of Ireland. The path of the depressions traversing this district is remarkably unimpeded; for while there exist no highly condensing surfaces in the more immediate neighbourhood, such as would tend to arrest the progress of the depressions, the Scandinavian or the Alpine ranges, or (in winter) the cold districts of Northern Germany and Denmark, exert a powerful attracting influence upon the minima, by condensing the vapour of the outlying currents, and the depressions take a sudden leap to the N.E., E., or S.E., as the case may be.

Little remains to be said of the depressions whose centres occupy the remaining districts, as their character has been already incidentally described. It is another

remarkable example of the effect of the absence of any highly condensing surfaces, that in no instance have either the winter depressions from the West and N. West, or the summer depressions from the South, remained stationary for upwards of twenty-four hours in Nos. XI. or XII. Several depressions of each class have undergone dissipation here, but in no case has the process occupied more than a few hours.

CHAPTER VII.

INSTANCES OF DEPRESSIONS IN A PRIMARY STAGE.

In the selection of examples I have been guided by the following considerations.

No instance of any system of atmospheric circulation is perfectly typical, *i.e.* devoid of any individual peculiarities derived from antecedent or accompanying atmospheric conditions, and therefore absolutely representative of a class. It is from the relatively small number of those which most nearly approach perfection of type that illustrative examples have to be chosen.

Subject to this primary consideration the desirability is evident of selecting those instances of which the fullest and most minute particulars have been ascertainable. The Observatory records and the weather reports of some few years back are deficient in accuracy as compared with those of the most recent period. Irrespective, too, of their greater value, the most modern instances are apt to possess the highest interest to a majority of readers.

In connection with this last consideration it has appeared rather desirable than the contrary to select, when otherwise opportune, those instances to which the attention of meteorologists has already been drawn by previous investigators. This would not have been the case had any distinct or tenable theories been adduced by them on the progression of baric areas; but in a subject of which the primary laws are now under in-

vestigation, the greatest interest still attaches to the best known and most familiar examples.

Several instances have been specially selected from the first half of the year 1869, on account of the immense advantages derivable from an examination of the registers of the seven observatories established by the Meteorological Committee in 1868, the records of whose self-registering instruments have been published in the quarterly weather reports of the Meteorological Office in 1870, from which the most valuable information has been drawn.

Besides the data above alluded to, the records of continental observatories have been largely employed. Much use has also been made of all obtainable rainfall returns in the British Isles. The records of private observers, notices of weather phenomena chronicled in the newspapers, mercantile ship reports, and a variety of other materials have been pressed into the service when available.

Some of the daily weather reports of the Meteorological Office, and of the 'Bulletin International' (the latter reduced to English scales and equivalents) are given *in extenso*, for purposes of reference and verification, at the conclusion of the account of each example.

INSTANCE I.

February 11–13, 1869.

The first instance which we select is one of a decidedly exceptional character as regards *extent*, the whole area of disturbance being unusually limited (even as compared with other depressions in a primary stage,

which are always small), a characteristic which, combined with a rather uncommonly high *intensity*, caused the accompanying storm to attract the attention of observers in an unusual degree.* But as regards the general antecedent conditions of the atmosphere with reference to the distribution of the pressure centres, it may be considered admirably typical, while the very limited dimensions of the circulation, as well as the geographical position of its development, are of the greatest advantage in enabling us to trace its relation to, and its effect upon, the outlying portions of the atmosphere. The operations of nature in the formation of the systems of retrograde currents are rarely conducted on a scale sufficiently *small* to enable her handwriting to be distinctly legible; consequently, instances like the one about to be described are of peculiar interest, as exhibiting the process in miniature.

In the latter part of January and throughout the first ten days of February, 1869, a series of depression areas swept over the West and North of the British Isles, the climax of the disturbance being attained in the last three days of the former month, when the East and S. East segments of these areas were felt as violent Southerly and S. Westerly gales on our shores, at the same time that the currents of the South and South-Western portions were experienced a little to the North of the Azores as violent West and N. West storms. These areas reached us for the most part in their secondary and tertiary stages, and several of them passed on in a widely expanded condition into Eastern Europe, moist and (for the season) warm equatorial currents being felt in the early part of February over a great part of

* See especially Mr. Glaisher's paper "On the Storm of February 12, 1869," 'Proceedings of the Met. Soc.,' No. 42; also the interesting reports of the same storm in Mr. Symons's 'Met. Magazine' for March, 1869.

Russia. Towards the conclusion of the period a node of high and gradually increasing pressure became developed in the Peninsula. About the 10th of February isobarics began to diverge somewhat in Western Europe, and the general decrease in the steepness of the gradients, accompanied by a diminution in the wind-force on our Western shores, seemed to point to some amelioration of the weather conditions, but the atmosphere continued to contain much water-vapour.

Plate V. is a map of the isobarics at 8 A.M. on the morning of the 11th in N. Western Europe. In the North lay two expanded depressions, both slowly travelling Eastwards, the central portion of one of these existing at Petersburg, and that of the other in Norway. Temperatures were now rapidly falling to their normal levels for the season in Sweden, Russia, and Central Europe. The circular high-pressure area whose centre existed in Spain was throwing out currents of moderate force to the Northward across the Bay of Biscay, these currents becoming more West, through the influence of the earth's rotation, in Northern France and Germany, where extensive but moderate precipitation continued throughout the day.

During this day, the Norwegian depression passing Eastwards, pressure rose steadily in the North of the British Isles, and temperatures declined. A region of almost complete baric uniformity and consequent atmospheric stagnation was thus produced over St. George's Channel. At 7 P.M. the greatest difference between the barometric readings at Valentia, Armagh, Stonyhurst, Falmouth, and Kew, was only ·08 in. At the entrance of St. George's Channel the atmosphere was extremely damp and warm, and here precipitation continued heavily and without cessation, under a con-

dition of atmospheric equilibrium. Over all the South and South-West of Great Britain lay a dense composite cloud-bank, the N. East border of which extended to Lancashire and Derbyshire, while Northward of those counties the sky was comparatively clear. At the entrance of the English Channel the belt of moderate equatorial current continued to supply the area of precipitation with fresh additions of moisture-laden atmosphere from the Atlantic.

At noon pressure, while increasing elsewhere, had begun sensibly to diminish in Devon and Cornwall in the focus of this great cloud-bank, and from this point the diminution spread very slowly in every direction, continuing, however, to be more brisk here than elsewhere. Consequently in the evening the atmosphere lying to the South of the area of precipitation, that being the direction in which pressures were highest, began to be vigorously attracted towards it, causing, according to the usual law, a freshening of S. West breezes on the S.E. limit of the precipitation; and shortly after midnight, pressure having become lower in the centre of the area than in Ireland and Wales, a light N.E. current began to be felt in the Irish Channel, and subsequently a faint Easterly breeze began to be experienced in the English Midlands, while winds and pressures in the North of Great Britain continued unaffected.

The commingling of the cool Northern breezes with the currents drawn from South tended further to precipitate the moisture of the latter; and at 8 A.M. of the 12th, as shown in Plate VI., the focus of precipitation had plainly developed an atmospheric circulation, of which the Northern portion, where baric differences were slight, consisted of feeble winds, while at the

entrance of the Channel, where gradients were becoming steep, the S.W. current blew with a velocity of nearly 40 miles an hour (without, however, producing much sea disturbance, the current not being extensive).

The Eastward development of the depression now became rapid, the warm atmosphere from the South coast of England coming in contact in its Northward motion with the cooler air in the Midlands, and having its water drained off in violent rain. From the entrance of St. George's Channel the baric minimum appears to have taken an E. by N. direction up the Bristol Channel, traversing Monmouthshire at 2, and skirting the South of Herefordshire at 2.30 P.M. From this point the track of the minimum was E.S.E. or E. by S., crossing Berkshire at 3.30. Thence it again trended to E. by N., and passed across Hertfordshire, crossing long. 0° at 4.35, along the South of Suffolk, to the coast, which it reached about 6.15 P.M., its motion of translation having been as rapid as 40 miles an hour.

During the passage of the depression there was only a slight increase in the extent of the helix, but the augmentation of intensity was very great indeed. At 8 A.M. the minimum readings of the barometer in the central calm, then situated over the coasts of the Bristol Channel, were about 29·78. In passing the longitude of Greenwich the minimum had become as low as 29·32. The intensity (or steepness of the barometric gradient) appears to have been everywhere greatest on the S.W. side of the baric minimum, and here, along our Channel coasts, and as far South as Guernsey, the N.W. current seems to have been generally felt with a force of about 14 lbs. on the square foot.

The curve of the currents in the neighbourhood

of the minimum was of so small a radius that in Herefordshire at 3.20 P.M., looking along a horizontal pole fixed in the direction in which the fragments of low cloud were passing over my head, I could distinctly *see* the gyration of the current, similar fragments of cloud on the North horizon plainly flying from a point E., and those on the South horizon from a point W. of the line of the pole. I have frequently seen the curvature of currents exhibited by this method, but never in so striking a degree. At that time the sky was tremendously black in the East (its appearance being rendered more peculiar by the fact that the ground was covered with snow), while in the S.W. it was as brilliantly clear.

Plate VII. represents the system at 2 P.M., and Plate VIII. is a synoptic barogram, exhibiting the changes of barometer (corrected and reduced) at the three Observatories of Falmouth, Stonyhurst, and Kew during the 11th, 12th, and 13th of February.

The kindness of observers has furnished me with a great amount of information in detail with respect to the great precipitation which was productive of so remarkable a loss of tension. Only the general results of the rainfall observations can here be described.

At a few points along the extreme South coast of Ireland the rainfall on the 11th, during the formation of the system, was upwards of 0·50 in., but in Waterford and Wexford less than ·30 fell, and on the East coast of Ireland the 11th and 12th were dry. Crossing to Wales we find a little less than 0·50 in Cardiganshire, Montgomery, and Cheshire, and a little more in Radnor and Shropshire. Eastward of these counties the Northern limit of the 0·50 fall crossed Derbyshire,

Nottingham, and Lincoln. On the N. Wales coast, in the Isle of Man, and over all the Northern counties of England, the weather was dry and rainless during the passage of the depression. Turning our attention to the Channel coasts we find the Southern limit of the half-inch rainfall to be, unlike the Northern, very irregular in outline. West of Exeter the rainfall from the commencement of the heavy fall on the 11th to its termination on the afternoon of the 12th, was almost everywhere considerably above 0·50. Along the North coast of Cornwall and Devon, the fall was generally as much as from 1·00 to 1·50; and also in parts of the South coast of Cornwall, as at St. Austell, there fell upwards of 1·50 in. East of Exeter quantities greatly in excess of 0·50 fell at various points along our Southern coast, but other districts seem to have escaped this heavy fall. North of lat. 51° 20′ the fall was generally greatly in excess of 0·50.

The heaviest rainfall was, however, in the actual track of the baric minimum. Along the South coast of Wales from St. David's to Chepstow the fall was generally much above an inch; and at some localities, as at Llanelly, considerably above two inches. From Monmouthshire to the Essex coast, along the track already described as that of the depression centre, the fall was upwards of one inch at nearly every locality from which I have received information; the width, however (from N. to S.), of this belt of great precipitation varied considerably, and was greatest in the Eastern counties. Altogether, on the lowest computation, we may assume that a deposit of upwards of one inch of water took place between the morning of the 11th and the night of the 12th over a tract of about 18,000 square miles, and a deposit of half that amount over a further tract

of 33,000 square miles. The abstraction of the stupendous volume of aqueous vapour represented by this deposit, taken in conjunction with the influence of the earth's rotation in retarding the supply of dry air for the partial vacuum produced, is undoubtedly dynamically capable of causing the great baric and atmospheric effects actually observed.

There was very little electric disturbance noticeable during the formation or passage of the system, and (except from Lowestoft, Surrey, and from Boulogne, where a little thunder took place on the 11th) I have received no accounts of electrical phenomena being anywhere observed.

The thermal phenomena peculiarly merit attention, for while exceptionally intense in degree they were in character highly representative of those which attend all systems of retrograde currents. The temperature of the currents experienced in front of a progressive baric depression is of course always high, and that of those in its rear always low, the former blowing from warmer and the latter from colder regions, according to the law described in a previous chapter. But the great fall of temperature which frequently attends the in-rush of polar winds subsequent to the transit of the depression centre is often such as cannot adequately be accounted for on the ground that these have come from higher latitudes; and it is of especial importance to observe that it is in the earlier stage of depressions, when the wind-curve is of small radius, and when, in short, the polar current has not come from regions much farther North, that the diminution of temperature is often most intensely felt. Thus in the instance before us a fall of temperature varying from 5° to 25° everywhere succeeded the passage of the baric minimum. In the

West Midlands at 2 P.M. thermometers had fallen to the freezing point in the Northerly wind, while in the Eastern counties, under the Southerly current, they stood at 50° or above. Yet at that time thermometers over the whole of the Northern portion of the British Isles, in the region *from which* the freezing current *came*, stood almost without exception at above 40°; and even in Sweden, Norway, the Orkneys, &c., at a great distance from this local current, temperatures were much higher than in the current itself. To what cause or combination of causes are we therefore to attribute so remarkable a depression of temperature?

Some meteorologists have accounted for the thermal depression by the hypothesis of a descending upper-current dipping from a considerable altitude into the lower strata of the atmosphere in the wake of the baric minimum. But, as we shall hereafter see, the evidence on the subject of the existence of such a descending current is entirely negative.

The twofold explanation which we shall hazard appears adequate to account for the phenomenon in question.

The aqueous vapour which the atmosphere contains is, not only in its visible but in a less degree in its invisible state, a most powerful agent in keeping up the temperature of the earth by admitting the direct solar heat, and at the same time checking the radiated heat. The vapour envelope suspended in the atmosphere has been aptly compared to the glass covering of a greenhouse; and it is, in fact, to the density of this envelope, spread by the Anti-trade currents over the Western shores of Europe that the mild character of our winters is principally due. Now, abnormally violent precipitation, by suddenly withdrawing a large

portion of the water-vapour and causing what may be termed a partial rupture in the envelope, may result in a rapid declension of temperature in the lower regions of the atmosphere towards such a level as is commonly experienced at the same latitude and at the same season of the year in Central Europe or America, or upon the summits of high hills. In connection with this view it should be remarked that the most rapid fall of temperature commonly, as was the case in the instance before us, succeeds the passage of the actual focus of precipitation, while at a distance on either side of its track the temperature fall is much less marked. The change in the *form* of precipitation, first from rain to hail, and subsequently to snow, as was noticed on the 12th of February in many localities, favours the supposition that the declension of temperature is felt earliest in the lowest, and afterwards propagated to the higher strata of the atmosphere.

Then, secondly, it must not be forgotten that the polar currents are strong evaporators, and the stream of dry air rushing over the moist surface of a soil previously drenched by violent rain, in its absorption of moisture renders latent a considerable body of caloric, thus greatly furthering for the time the reduction of temperature.

In a perpendicular direction the extension of the wind-system, whose development has been described, appears to have been very limited, the circulation, as is frequently the case in the earlier stages of depressions, being apparently confined to the inferior strata of the atmosphere. Elevated Cirrus clouds seem to have moved generally from W.S.W., the current slowly veering to W.N.W. both in the track of the depression and in the more Northern counties. This upper current

was, however, of remarkable rapidity in the immediate rear of the depression.

Laterally the greatest Northward extension of the Easterly current was not above 230 miles from the centre of depression. The distance at which the barometric oscillation was felt was, as is frequently the case, much greater than the extension of the actual wind-system, and even as far North as Aberdeen the depression was experienced to the extent of about ·16 in. In the South, the area of high pressure in the Peninsula which supplied the S. Westerly current gave way to the amount of about ·20 in., and in Central France pressures diminished as much as ·35 between 6 P.M. of the 11th and 6 P.M. of the 12th, but then recovered and again attained a very high level.

Our investigation of this instructive depression would not be complete without a few brief remarks upon its subsequent career, so far as we are able to trace it, and upon the weather which immediately succeeded.

Its intensity appeared to be still on the increase when it left our East coast on the evening of the 12th. At 6 P.M. it blew a "hurricane" from N.N.E. at Lowestoft, and from N.N.W. at Margate, and owing to its suddenness and the rapidity of the change of wind, the gale proved very destructive to a number of small vessels on the Norfolk, Essex, and Kentish coasts. At the same time a strong W.S.W. gale was felt in the N. East of France. On reaching Belgium and Holland the whole system seems to have begun to collapse; and although on the morning of the 13th a slight barometric fall was experienced in Northern Germany, yet the depression appears to have been nowhere serious, and we have no intelligence of any accompanying storms: our informa-

tion from Central Europe is, however, very defective indeed.

Judging from other examples of the sudden collapse of small and intense depressions, we may, perhaps, attribute the annihilation of the system at this point, not so much to the fact that the Southerly currents now became land winds, and therefore less charged with water-vapour —for in many instances depressions on this same track are found to undergo further development—but rather to the influence of the extensive precipitation which had prevailed almost without cessation throughout Germany on the 11th and 12th, and by which the supplies of vapour in this direction had been already drained off.

While on the 12th the intense depression was crossing our Southern counties, a supplementary disturbance, the region of whose development must have lain a few hundred miles to the W., approached the Irish coast, advancing towards N.N.E. The wind at Valentia shifted to S. a little before noon, with rain; and pressure, which had there been very slightly affected by the English disturbance, diminished rapidly, attaining its lowest level, 29·71, at 5 P.M., when the wind veered to N.W., with an extremely brisk recovery. The oscillation was strongly felt at Falmouth a little before midnight: at the other Observatories it was blended with that caused by the English depression. The sudden and unusual disappearance of this depression also may probably be attributed to the "drying process" which the atmosphere in the S.W. of our islands had undergone, immediately previous to its approach, in the storm of the 12th.

On the 13th weather continued unsettled, and a great depression approached the Norwegian coast from W.N.W.,

its Southern arc being slightly felt in Scotland. On the 14th this depression was of extreme intensity, passing first to E., and subsequently to E.N.E., across Finland and Northern Russia, affecting the currents over all Northern Europe.

METEOROLOGICAL REPORTS.

February 11, 1869.—8 a.m.

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Haparanda ..	29·69	7	—	N.W.	3	—	—	b.	—	2
Petersburg ..	29·28	23	—	Z.	0	—	—	o. s.	—	—
Hernosand ..	29·52	17	—	N.E.	4	2	N.W.	o.	—	3
Stockholm ..	29·56	22	—	N.W.	2	—	—	b.	—	—
Skudesnæs ..	29·34	39	—	W.	2	2	S.S.W.	o.	—	3
Helder	29·93	47	—	W.S.W.	8	—	—	r.	—	4
Brussels ..	30·07	53	—	S.W.	6	—	—	o. r.	—	—
Strasburg ..	30·21	55	—	W.	3	—	—	r.	—	—
Paris	30·34	53	—	W.S.W.	4	8	W.S.W.	o.	...	—
Cape Gris Nez	30·06	50	50	W.	8	9	W.S.W.	r. t.	0·06	6
Kew	30·06	53	52	W.	3	7	W.S.W.	c. r. o.	0·01	—
Yarmouth ..	29·96	52	51	W.	3	7	W.N.W.	o. m.	...	3
Scarborough ..	29·88	42	41	W.S.W.	2	7	W.	c.	0·10	2
Shields	29·80	45	42	W.	7	6	W.	c.	0·40	2
Aberdeen ..	29·68	38	37	S.W.	1	1	S.W.	b.	...	1
Nairn	29·63	39	37	S.W.	5	1	S.W.	c. b. o.	0·04	2
Glasgow ..	29·83	42	40	W.S.W.	5	2	W.S.W.	—	0·28	—
Ardrossan ..	29·84	46	42	N.W.	5	2	S.W.	c.	0·14	4
Stonyhurst ..	29·96	49	48	W.S.W.	4	7	S.W.	—	0·88	—
Holyhead ..	29·97	47	45	S.W.	2	8	S.S.W.	o.	0·10	—
Greencastle ..	29·91	42	40	W.N.W.	3	1	S.W.	r. c.	0·04	—
Valentia ..	30·09	49	47	W.N.W.	2	6	S.W.	r. m. o.	0·08	2
Roche's Point	30·08	48	46	W.	2	5	W.S.W.	c.	...	2
Falmouth ..	30·16	51	51	W.S.W.	4	7	W.S.W.	—	—	3
Plymouth ..	30·16	52	51	W.S.W.	3	7	S.W.	m. r.	0·30	4
Portsmouth ..	30·10	52	51	W.	4	6	W.S.W.	r.	0·14	4
Havre	30·24	53	—	W.	4	6	W.S.W.	r.	—	5
Cherbourg ..	30·16	51	—	S.W.	5	6	W.S.W.	r.	—	5
Brest	30·32	52	52	S.W.	4	7	S.W.	m.	0·01	3
L'Orient ..	30·34	52	52	S.W.	6	7	S.W.	r.	0·03	5
Rochefort ..	30·47	52	50	S.W.	5	5	S.W.	o.	...	2
Limoges ..	30·50	50	—	W.	3	3	N.	r.	—	—
Montauban ..	30·64	43	—	W.	3	3	S.W.	b.	—	—
Biarritz	30·58	54	49	?	3	—	—	b.	...	4
Bilbao	30·51	48	—	S.W.	2	—	—	b.	—	3
Corunna ..	30·43	56	—	S.W.	3	4	N.E.	c.	—	2

FEBRUARY 11, 1869.—8 A.M.—*continued.*

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Lisbon	30·66	53	—	N.N.E.	2	—	—	c.	—	2
Alicant	30·66	56	—	N.E.	2	—	—	b.	—	0
Madrid	30·73	38	—	N.	2	—	—	b.	—	—
Perpignan ..	30·56	53	—	W.	3	—	—	c.	—	0
Cette	30·51	59	—	N.W.	3	3	W.	b. c.	—	0
Lyons	30·51	53	—	N.	3	4	N.W.	f.	—	—
Marseilles ..	30·47	50	—	N.	3	5	N.W.	c. f.	—	1
Toulon	30·38	50	46	N.N.W.	7	8	W.N.W.	b. f.	...	5
Berne	30·42	50	—	W.	5	4	W.	r.	—	—
Leghorn ..	30·37	53	—	S.	2	3	W.	f.	—	0
Rome	30·39	45	—	N.W.	3	—	—	b. c.	—	2
Naples	30·43	48	—	W.S.W.	3	3	N.W.	c.	—	2
Palermo ..	30·38	48	—	S.W.	1	—	—	b.	—	2
Ancona	30·21	43	—	W.	2	—	—	f.	—	4
Lesina	30·26	47	—	E.	3	—	—	b. c.	—	2
Trieste	30·29	45	—	S.E.	2	—	—	o. f.	—	2
Vienna	30·01	49	—	W.	9	—	—	o. r.	—	—
Odessa	29·75	36	—	S.W.	1	—	—	c.	—	0
Moscow	29·25	35	—	W.	3	—	—	c.	—	—

2 P.M.

Aberdeen ..	29·80	43	37	W.N.W.	3	—	—	c.	—	—
Scarborough ..	29·96	49	45	W.	3	—	—	c.	—	2
Stonyhurst ..	29·99	48	44	W.	4	—	—	c.	—	—
Greencastle ..	29·97	42	40	W.	3	—	—	r. c.	—	—
Valentia ..	30·15	50	47	W.N.W.	1	—	—	m. o.	—	1
Falmouth ..	30·16	52	52	W.S.W.	5	—	—	r.	—	4
Kew	30·10	55	52	W.N.W.	2	—	—	o.	—	—
Paris	30·31	56	—	W.S.W.	5	—	—	o.	—	—
Rochefort ..	30·50	54	54	W.	5	—	—	f.	—	—

FEBRUARY 12, 1869.—8 A.M.

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Haparanda ..	29·68	6	—	S.E.	3	—	—	o.	—	—
Petersburg ..	29·60	17	—	E.	2	—	—	o.	—	—
Riga	29·57	29	—	S.	2	—	—	—	—	—
Hernosand ..	29·52	16	—	Z.	0	—	—	s.	—	—
Stockholm ..	29·51	25	—	N.N.E.	2	—	—	s.	—	—
Christiansund	29·42	34	—	N.	5	—	—	—	—	3
Skudesnæs ..	29·70	37	—	N.W.	2	5	W.N.W.	c.	—	3

FEBRUARY 12, 1869.—8 A.M.—*continued.*

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Groningen ..	30·00	41	—	W.S.W.	1	—	—	o.	—	—
Leipzic	—	—	—	W.	—	—	—	r. o.	—	—
Helder	30·00	44	—	W.	2	—	—	o.	—	
Brussels ..	30·01	50	—	W.S.W.	3	—	—	r.	—	—
Strasburg ..	30·20	54	—	S.W.	3	6	W.	r.	—	—
Paris	30·16	52	—	S.S.W.	2	6	S.W.	o.	...	—
Cape Gris Nez	29·94	48	48	W.	9	8	W.S.W.	r.	0·13	—
Kew	29·93	44	43	E.	2	3	W.S.W.	o. r.	0·50	—
Yarmouth ..	29·96	44	43	S.	2	3	W.N.W.	o.	—	2
Scarborough ..	29·95	39	37	W.N.W.	1	3	W.	c. f.	—	2
Shields	29·93	43	42	S.W.	1	4	N.W.	c. f.	—	2
Aberdeen ..	29·84	35	34	W.S.W.	1	3	W.	b. o.	—	1
Nairn	29·76	36	34	S.W.	1	5	S.W.	o. r. b.	0·05	1
Glasgow ..	29·87	37	35	W.S.W.	1	5	W.S.W.	c.	0·11	—
Ardrossan ..	29·91	42	39	W.S.W.	3	4	W.	c.	0·14	3
Stonyhurst ..	29·94	38	36	N.N.E.	1	5	W.	c.	0·01	—
Holyhead ..	29·93	42	40	E.S.E.	2	3	S.W.	c. o.	...	—
Greencastle ..	29·88	38	37	N.W.	1	4	W.N.W.	r. h. c.	0·08	—
Valentia ..	29·95	44	42	Z.	0	2	N.W.	m. r. o.	0·05	0
Roche's Point	29·89	40	40	N.E.	4	4	N.E.	r.	0·62	2
Falmouth ..	29·82	50	49	S.W.	8	7	S.W.	r.	—	4
Plymouth ..	29·91	51	50	W.S.W.	7	5	W.S.W.	r.	0·35	5
Portsmouth ..	29·91	51	50	W.S.W.	6	6	W.S.W.	r.	0·51	5
Havre	30·04	52	—	S.W.	5	6	W.S.W.	o.	—	5
Cherbourg ..	29·95	51	—	S.S.W.	3	5	W.S.W.	o.	—	5
Brest	30·04	52	50	S.W.	7	7	S.W.	o.	...	4
L'Orient ..	30·18	52	50	S.W.	5	5	S.W.	o.	...	4
Rochefort ..	30·35	52	50	W.	4	5	W.	o.	...	3
Limoges ..	30·35	50	—	S.E.	3	3	S.E.	r.	—	—
Montauban ..	30·46	45	—	S.E.	3	3	N.W.	f.	—	—
Biarritz	30·41	50	48	N.W.	3	—	—	c.	...	—
Bilbao	30·37	50	—	W.	3	—	—	c.	—	3
Corunna ..	30·49	56	—	S.W.	3	3	W.	c.	—	—
Lisbon	30·56	51	—	N.N.E.	2	—	—	c.	—	2
Alicant	30·48	52	—	N.W.	1	—	—	b.	—	1
Madrid	30·60	36	—	N.	2	—	—	b.	—	—
Perpignan ..	30·40	53	—	W.	1	—	—	b.	—	—
Cette	30·35	57	—	N.	4	4	N.W.	c.	—	0
Lyons	30·43	52	—	N.	3	2	S.	c.	—	—
Marseilles ..	—	—	—	N.	3	—	—	c.	—	4
Toulon	30·25	52	—	W.N.W.	5	6	W.N.W.	f. c.	—	5
Berne	30·36	48	—	Z.	0	—	—	b. c.	—	—
Leghorn ..	30·27	48	—	S.S.E.	3	—	—	o.	—	—
Rome	30·28	40	—	N.W.	—	—	—	—	—	3
Naples	30·32	53	—	W.S.W.	3	3	S.W.	b. c.	—	2
Palermo ..	30·26	49	—	W.S.W.	3	2	E.N.E.	b.	—	2
Ancona	30·20	45	—	W.	3	3	W.	f.	—	3
Trieste	30·27	36	—	E.	1	—	—	f.	—	—
Vienna	30·01	44	—	S.S.W.	3	5	W.	o. r.	—	—
Constantinople	30·04	45	—	N.	3	—	—	o.	—	—
Odessa	29·70	?	—	N.W.	3	—	—	o.	—	—

February 12, 1869.—2 p.m.

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Aberdeen ..	29·72	42	38	S.W.	1	—	—	b.	—	1
Scarborough ..	29·78	42	40	E.N.E.	2	—	—	f. o.	—	2
Stonyhurst ..	29·76	40	36	N.E.	1	—	—	p. s.	—	—
Greencastle ..	29·75	44	41	S.W.	3	—	—	c.	—	—
Valentia ..	29·85	48	46	S.W.	4	—	—	r. o.	—	4
Falmouth ..	29·93	45	42	N.W.	5	—	—	r. c.	—	4
Kew	29·57	51	50	S.W.	7	—	—	r. o.	—	—
Paris	30·00	53	—	S.W.	7	—	—	c.	—	—
Rochefort ..	30·26	54	52	S.W.	7	—	—	o.	—	2

February 13, 1869.—8 a.m.

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Haparanda ..	29·46	15	—	S.E.	3	—	—	o.	—	3
Petersburg ..	29·72	9	—	S.W.	5	—	—	o.	—	—
Riga	29·64	27	—	S.W.	2	—	—	o.	—	—
Hernosand ..	29·43	1	—	Z.	0	—	—	b.	—	—
Stockholm ..	29·55	18	—	W.N.W.	2	3	N.N.E.	o. f.	—	—
Christiansund	29·25	37	—	S.S.W.	6	—	—	o.	—	3
Skudesnæs ..	29·71	37	—	S.S.W.	3	4	W.S.W.	c.	—	2
Groningen ..	30·04	38	—	W.N.W.	1	—	—	c.	—	—
Leipzic	29·78	43	—	N.N.W.	—	—	—	o. r.	—	—
Helder	30·06	50	—	N.W.	1	—	—	—	—	—
Mézières ..	—	31	—	N.	2	6	W.	o.	—	—
Strasburg ..	30·12	44	—	N.W.	5	4	S.W.	b. c.	—	—
Paris	30·24	41	—	N.N.E.	2	8	W.S.W.	b. c.	...	—
Kew	30·22	39	36	W.N.W.	2	9	N.	o. b. c.	0·32	—
Yarmouth ..	30·15	34	34	W.N.W.	3	10	N.N.E.	r. m.	1·12	3
Scarborough ..	30·16	36	34	W.N.W.	2	2	E.N.E.	f. o. b.	...	2
Shields	30·15	39	36	W.	2	2	W.N.W.	c. m.	...	2
Aberdeen ..	29·92	40	38	W.S.W.	1	1	S.W.	b. o.	0·05	1
Nairn	29·88	38	36	S.W.	4	1	N.W.	b. o. c.	0·05	2
Glasgow ..	30·11	43	40	W.S.W.	5	3	N.W.	b. o. r.	0·10	—
Ardrossan ..	30·13	46	42	W.N.W.	6	8	W.	c.	...	4
Stonyhurst ..	30·24	38	36	W.N.W.	3	2	W.	c.	0·01	—
Holyhead ..	30·29	43	40	W.N.W.	4	8	S.S.W.	c.	0·05	—
Greencastle ..	30·19	42	40	W.	3	5	N.W.	r. c.	0·06	—
Valentia ..	30·49	46	42	N.W.	4	9	N.N.W.	o. r. c.	0·14	3
Roche's Point	30·45	42	40	W.N.W.	3	7	W.	o. b.	0·15	2
Falmouth ..	30·43	44	40	N.N.W.	4	10	N.W.	r. b.	—	3
Plymouth ..	30·37	43	41	N.	3	9	N.N.W.	r. b.	0·27	3
Portsmouth ..	30·29	40	39	N.W.	4	10	N.N.W.	r. c.	0·21	1
Havre	30·24	43	—	S.S.E.	1	10	W.S.W.	o.	—	5
Cherbourg ..	—?	45	—	N.N.W.	2	9	W.S.W.	c.	—	4
Brest	30·36	46	—	N.N.W.	5	8	N.W.	o.	—	4
L'Orient ..	30·27	45	—	N.	4	6	W.N.W.	c.	—	3

FEBRUARY 13, 1869.—8 A.M.—*continued.*

STATION.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Rochefort ..	30·24	46	42	W.	4	6	S.W.	c.	—	3
Limoges ..	30·16?	40	—	W.	2	3	N.	r.	—	—
Montauban ..	30·25	50	—	S.W.	3	3	N.W.	r.	—	—
Biarritz	30·27	50	—	N.	6	—	—	r.	—	5
Bilbao	30·40	50	—	N.W.	3	—	—	o.	—	4
Alicant	30·22	66	—	N.	5	—	—	b.	—	1
Madrid	30·38	43	—	N.	3	—	—	b.	—	—
Barcelona ..	30·08	54	—	W.	3	—	—	b.	—	2
Perpignan ..	30·16	56	—	N.W.	5	—	—	—	—	—
Cette	30·16	59	—	N.W.	3	3	W.	b. c.	—	1
Lyons	30·18	50	—	N.	3	3	N.W.	b. c.	—	—
Marseilles ..	30·19	50	—	N.W.	5	4	N.W.	b.	—	4
Toulon	29·99	50	—	N.W.	7	5	N.W.	c. b.	—	6
Antibes	—	—	—	N.N.E.	3	3	S.W.	o.	—	1
Berne	30·14	43	—	W.	1	—	—	o.	—	—
Leghorn ..	30·02	55	—	E.N.E.	3	—	—	o.	—	0
Rome	30·03	52	—	S.W.	3	—	—	o.	—	5
Naples	30·08	52	—	W.S.W.	3	3	S.S.W.	c.	—	—
Palermo ..	29·97	48	—	Z.	0	—	—	b.	—	0
Ancona	29·95	46	—	W.	3	3	S.	f.	—	0
Constantinople	30·04	48	—	W.S.W.	1	1	S.E.	b.	—	—
Odessa	29·69	35	—	N.W.	4	—	—	b.	—	1

2 P.M.

Aberdeen ..	29·83	45	41	S.W.	4	—	—	c.	—	2
Scarborough ..	30·20	46	43	W.	2	—	—	b. c.	—	2
Stonyhurst ..	30·29	46	41	W.S.W.	5	—	—	c. o.	—	—
Greencastle ..	30·09	45	43	W.S.W.	5	—	—	c. o.	—	—
Valentia ..	30·50	48	45	W.	5	—	—	o. c.	—	4
Falmouth ..	30·56	48	44	N.W.	2	—	—	b.	—	2
Kew	30·40	47	43	N.W.	2	—	—	c. b.	—	—
Paris	30·38	48	—	N.N.W.	3	—	—	b.	—	—
Corunna ..	30·62	50	—	W.	5	—	—	c.	—	5

FEBRUARY 14, 1869.—8 A.M.

STATION.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Haparanda ..	29·00	16	—	S.E.	6	—	—	o. s.	—	—
Petersburg ..	29·53	40	—	S.	3	—	—	o.	—	—
Hernosand ..	28·68	39	—	S.S.W.	5	—	—	o.	—	—
Stockholm ..	29·48	36	—	S.S.W.	3	—	—	r.	—	—
Groningen ..	30·04	43	—	S.W.	8	—	—	o.	—	—
Leipzic	30·29	36	—	S.S.W.	3	—	—	b. c.	—	—

FEBRUARY 14, 1869.—8 A.M.—*continued.*

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Strasburg ..	30·49	36	—	N.W.	3	—	—	b. m.	—	—
Paris	30·53	40	—	S.W.	2	2	W.N.W.	—	—	—
Kew	30·30	46	43	W.	5	3	W.S.W.	b. c.	...	—
Aberdeen ..	29·46	45	42	W.N.W.	5	8	W.S.W.	r. c.	—	—
Stonyhurst ..	30·08	46	43	W.S.W.	7	7	S.W.	c.	0·02	—
Valentia ..	30·33	49	48	S.W.	8	9	S.S.W.	o. c.	0·03	7
Falmouth ..	30·52	46	43	W.	4	4	W.	c.	—	3
Cherbourg ..	30·46	48	—	W.	4	3	N.	o.	—	5
Brest	30·60	46	—	W.	1	1	N.N.E.	o.	—	3
Rochefort ..	30·65	40	—	N.	2	3	W.	b.	—	2
Bilbao	30·62	41	—	N.W.	2	—	—	c.	—	4
Perpignan ..	30·47	47	—	N.W.	8	7	N.W.	b.	—	5
Marseilles ..	30·31	43	—	N.	3	5	N.W.	b.	—	4
Berne	30·52	31	—	E.	1	1	N.E.	b.	—	—
Leghorn ..	30·25	48	—	E.	7	2	E.N.E.	b.	—	5
Naples	30·11	50	—	N.E.	3	2	W.S.W.	b. c.	—	0
Palermo ..	29·98	48	—	W.S.W.	1	3	N.E.	b. c.	—	0
Lesina	30·18	48	—	N.E.	6	—	—	r.	—	5
Trieste	30·45	45	—	N.E.	5	—	—	b.	—	4
Vienna	30·39	36	—	W.N.W.	6	—	—	b.	—	—

INSTANCE II.

March 18–22, 1869.

Strictly speaking, the actual initial formation of the depression now to be described took place a little to the West of our region of regular observation, but as it entered that region in a very early stage of development, and as it presents interesting points both of similarity and of contrast to the disturbance of February 12th, its career may be advantageously examined in the present chapter.

An unsettled period had again preceded the formation of this system; but the disturbances were more severely felt in Southern than in Northern Europe, a series of depressions of considerable intensity traversing

the Peninsula, Southern France, and Italy, while in the extreme North pressures were generally high. On the 16th, however, the Northern pressures gave way, a formidable depression approaching the Western coast of Ireland. The centre of this circulation advanced N. Eastwards to Cumberland on the 17th, when precipitation in its N. East arc was arrested, the central pressures recovered, and the system showed signs of breaking up. On the 18th the centre of this expanded and now almost dissipated and stationary depression lay in the North of Scotland, while off the Western coast of Spain an area of pressure of above 30·20 existed. In the evening pressures in the West of the British Isles were rapidly tending to uniformity, as shown in the accompanying barogram exhibiting the pressure curves at Glasgow, Valentia, Falmouth, and Kew. Winds accordingly became very light on our Western shores; but the sky was in the evening overcast with a dense canopy of nimbus, and heavy and continuous precipitation commenced over all the West coast of Ireland. The existence of light Southerly currents at Valentia about midnight prove the centre of the incipient depression to have been then off the coast; but at 3 A.M. the wind veered a little and freshened greatly, precipitation becoming extremely heavy in the midland counties of Ireland. The minimum appears to have passed the longitude of Valentia, but to the Northward of that station, a little before 7 A.M., when the wind veered to N.W., blowing a violent gale, and temperature fell 9°. A S.W. gale simultaneously commenced in St. George's and at the entrance of the English Channels, while a draught of S.E. wind began to be felt in the Irish Sea. At 8 A.M. the helix, as shown in Plate X., was complete, but of very limited extent. Heavy precipitation now

continued to occur in the Eastern arc, and the development of the system was nearly W. to E., the minimum advancing in the wake of the greatest precipitation with a rapidity of 40 miles an hour. The circulation at this point was not quite, though very nearly, of sufficient extent for its moisture-laden Southerly currents to reach the high lands of North Britain, in which case it might have been expected to travel towards the North. Very little rain fell in Cumberland and Lancashire, while in North Wales and in the English Midlands it was heavy.

The present system, like that previously examined, was an intense and rapidly-moving circulation entering the S. Western arc of an old and expanded depression. Consequently pressures on its N. Eastern were very much lower than on its S. Western limits, and the Easterly current was comparatively feeble, while the Westerly was extremely violent; Holyhead, and subsequently Yarmouth, were the only stations where the former current attained the force of a gale, while at Falmouth the mean hourly velocity of the N.W. current was 71 miles from 3 to 5 P.M., and throughout the Channel the storm was felt with great severity.

Plate XI. represents the system at 2 P.M. of the 19th when the central calm was over Wales. At that time the light Westerly airs of the old depression continued to be experienced in Scotland, and the E. wind was not felt at a greater radius than 150 miles from the baric minimum. The diameter of the area of pressure below 29·50 was about 300 miles.

The Northerly current reached Herefordshire at 6.20 P.M., a dead calm being succeeded in a few minutes by a strong polar gale, and a dash of rain changing

immediately to hail and then to snow, when temperature fell 14°, and the sky suddenly cleared in the W. A precisely similar change took place all across the English Midlands, reaching London at 10.30 P.M. The wind blew with a S.E. to N.N.E. gale at Yarmouth, and a S.W. to N.N.W. at Dover.

Comparing the present depression with that of February 12th we observe that with regard to *extent* its rate of increase was very much greater; but with regard to the *diminution of central pressure* very much less, and lastly, that its *intensity*, as measured by the steepness of the barometric gradients, rather diminished than increased as the system advanced to the East, at least as regards the Southern arc of the circulation. Each of these elements bears an intimate relation to the stage of development at which the system had arrived, and to the character of the precipitation taking place in it.

The latter, while very extensive, and for the most part remarkably uniform, was not exceptionally heavy in the majority of districts. The following rainfalls (those at least in Great Britain, for rainfall reports from Ireland are very defective) are selected as pretty fairly representing the mean fall of the tracts traversed by the different segments of the area (exclusive however of very elevated localities, from which it is seldom possible to obtain returns for any particular day).

Along the Northern limit of the cloud-bank, and altogether outside the central calm—

Greencastle ..	0·26	Glasgow	0·03	Durham	0·06
Strabane	0·19	Dumfries	0·06	Stonyhurst	0·35
Antrim	0·20	Keswick	0·19	Skipton	0·29
Warringston ..	0·33	Ulverston	0·24	Scarborough ..	0·28
Armagh	0·41	Leith	0·04	York	0·37
Ardross	0·18	Allenheads	0·09		

Along the Southern limit—

Cape Clear	0·31	Cardiff	0·46	Torquay	0·30
Roche's Point ..	0·35	Bridport	0·60	Lyme Regis ..	0·70
Waterford	0·51	Bideford	0·57	Portsmouth ..	0·34
Enniscorthy ..	0·46	Penzance	0·51	Brest	0·06
Pembroke	0·25	St. Austell	0·63	L'Orient	0·06
Llanelly	0·38	Plymouth	0·70	Paris	0·45

Nearer to, or within, the central portion of the cloud-bank—

Valentia	0·78	Buxton	0·52	Boston	1·18
Galway	0·84	Shiffnall	0·82	Leicester	0·80
Bunninadden ..	1·01	Tenbury	0·53	Oxford	0·72
Bawnboy	0·81	Ross	0·39	Banbury	0·62
Killaloe	0·49	Cirencester	0·64	Marlborough ..	0·53
Dublin	0·40	Cheltenham ..	0·48	Staplehurst	0·66
Holyhead	1·06	Manchester ..	0·44	London	0·23
Liverpool	0·78	Derby	0·56	Yarmouth	1·92
Belturbet	1·00	Tredegar	0·55	Lowestoft	2·02

The fall at the two last-mentioned stations is inclusive of that which occurred on the 20th in the Northerly current, which precipitated on the Suffolk and Essex coast a slightly larger quantity than fell in the Southerly current on the 19th. This polar rainfall, the precipitation of North Sea vapour, though extending over a limited belt of country, was productive of sensible baric effects in temporarily checking the Eastward progress of the system, the 29·50 isobaric advancing in the 24 hours subsequent to 8 A.M. of the 20th only half the distance traversed on the preceding day.

The currents of the S. Eastern arc of this already extensive circulation now began to be strongly felt over the great European watershed, on which the Atlantic vapour was discharged in violent rain and snow, while the light S.E. currents now experienced in Denmark, N. Germany, &c., were of a dry though cloudy character. Consequently the minimum suddenly took a more Southerly course, tension giving way with rapidity in the S. East. The pressure-changes in the East between

8 A.M. of the 19th and the same hour of the 20th were as follows:—

Berne	—·50	Stockholm	—·18
Vienna	—·30	Skudesnæs	—·01
Leipzic	—·37		

Plates XII. and XIII. represent the atmospheric conditions in Western Europe on the mornings of the 20th and 21st. On the former the area of pressure below 29·50 continued to maintain its circular form, while its diameter in the preceding 24 hours had been more than tripled. In the same period of time the greatest diameter of the whole area of atmosphere affected, or drawn into circulation, had increased from about 320 to about 1200 geographical miles, the whole of Europe now feeling the effects of the disturbance, and the barometric oscillation extending from Lisbon to St. Petersburg.

In the extreme South of Europe pressures had hitherto been on the increase, through the disappearance of a previous system of disturbance; but on the afternoon of the 20th heavy rain, hail, and thunder, with a violent sirocco, occurred on the Italian coast and in the Adriatic, pressures again rapidly gave way in the S.E., and the barometer readings over this district at 8 A.M. of the 21st exhibit the following changes since 8 A.M. of the preceding day:—

Leghorn	—·24	Ancona	—·36
Naples	—·28	Lesina	—·41
Palermo	—·27	Trieste	—·33

On the 21st the system entered its final stage, the contour of the lower isobarics became irregular, the weather became comparatively fine on the Mediterranean coasts, precipitation being generally arrested. The

polar gales which the depression had established in Western Europe now began to sweep towards the West, under the influence of the earth's rotation, the attracting force of the depression in the S.E. being diminished; and an area of high pressure became developed in the North of the British Isles. The general weather conditions which succeeded were very similar to those which preceded the depression.

The system above described may be contrasted with Instance I., principally in this respect, that the atmospheric conditions immediately preceding its formation were such as to favour instead of checking its ulterior development. There is, however, another and highly important point of dissimilarity, which we must now briefly describe, deferring a further consideration of it to the chapter on Upper-currents. During the translation of the retrograde system of the 19th across England, W.N.W. to W.S.W. upper-currents of moderate velocity prevailed above the Eastern arc of the circulation, but in the afternoon, during the passage of the light variable under-currents across the Midland counties, whiffs and striæ of elevated Cirrus could be seen through breaks in the lower cloud-bank, travelling slowly from E. and E by S., while in the more Northern counties a S.W. upper-current prevailed. On the 20th when the sky was comparatively clear, the phenomenon was far more distinctly observable: these elevated striæ moved with a brisk S.E. upper-current across the more Southern counties above the Northerly gale, while in the more Northern counties a rapid upper-current was observed from S.S.W. There existed in short a true system of direct currents, or "anti-cyclone," in the higher regions of the atmosphere, whose axis must have nearly corresponded with that of the retrograde circulation in the

lower! Whether or not the Easterly upper-current extended as far to the South on the 19th as the Channel coasts or Northern France, above the strong W. under-current, I have no information. I have never myself witnessed an Easterly Cirrus-current above a true *Westerly gale* (though the converse phenomenon is exceedingly common).

The elevated clouds which travelled with this upper-current were evidently altogether above, and separated from, the composite nimbus from which the rainfall of the 19th was precipitated, and even the lofty summits of those clouds which accompanied the lightning and hail squalls of the 20th did not combine with the former, but travelled with the Northerly under-current, though visibly swept or trailing backwards, as if penetrating a region of the atmosphere which was comparatively calm.

On the 21st the S. Easterly upper-current continued in the Southern counties and extended itself to the Northern, but its velocity was less. I have received no Cirrus observations for the 22nd.

Plate XIV. is a chart of the mean isothermals in Western Europe (previous to the formation of the helix), the track of the baric minimum, and the expansion of the 29·50 isobaric.

METEOROLOGICAL REPORTS.

MARCH 18, 1869.—8 A.M.

STATION.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Haparanda ..	30·19	27	—	S.	2	3	E.S.E.	o. s.	—	—
Hernosand ..	30·10	33	—	S.	2	—	—	o.	—	—
Stockholm ..	30·11	35	—	E.S.E.	3	—	—	o. s.	—	—
Christiansund	29·87	37	—	Z.	0	—	—	o.	—	4
Skudesnæs ..	29·89	37	—	S.E.	2	4	E.S.E.	o.	—	2
Groningen ..	29·86	34	—	E.	1	—	—	—	—	—
Leipzic	29·89	36	—	E.	3	—	—	o.	—	—
Helder	29·86	39	—	N.N.W.	2	—	—	b.	—	—
Brussels ..	29·89	40	—	N.E.	1	—	—	b.	—	—
Strasburg ..	29·80	37	—	S.W.	1	3	N.E.	o.	—	—
Paris	29·92	39	—	S.E.	2	3	S.E.	r. o. b.	0·18	—
Cape Gris Nez	29·70?	37	35	N.E.	1	8	S.E.	o. b.	...	0
Kew	29·92	37	36	E.S.E.	1	5	S.	r. b. o.	0·01	—
Yarmouth ..	29·88	40	38	W.S.W.	2	6	S.E.	c. m.	...	2
Scarborough	29·84	37	35	S.	3	6	S.E.	c. o.	...	2
Shields	29·73	38	36	S.W.	2	2	E.	c. f. o.	...	2
Aberdeen ..	29·65	38	37	S.	1	1	S.E.	c. o.	0·05	3
Nairn	29·58	40	37	S.W.	1	1	S.E.	c. b. o.	...	1
Glasgow ..	29·70	40	38	S.	2	4	E.N.E.	c. r.	0·04	—
Ardrossan ..	29·67	43	41	S.S.W.	3	4	E.N.E.	c. r.	0·02	3
Stonyhurst ..	29·79	38	35	S.W.	2	4	E.	o. c.	0·07	—
Holyhead ..	29·79	44	42	S.S.W.	4	6	E.N.E.	o. c.	...	—
Greencastle ..	29·62	46	43	W.S.W.	4	5	E.	o. r. c.	0·03	—
Valentia ..	29·95	48	45	N.W.	6	8	N.N.W.	o. r. c.	0·10	4
Cape Clear ..	29·89	48	46	N.W.	8	5	N.	c.	0·05	5
Roche's Point	29·86	46	45	W.	1	6	N.	c. f. b.	0·05	2
Pembroke ..	29·87	47	45	W.S.W.	3	3	N.N.W.	c.	...	3
Falmouth ..	29·94	46	44	N.W.	1	4	W.N.W.	r. f.	—	1
Plymouth ..	29·95	43	42	Z.	0	3	N.W.	c. h. f.	0·66	0
Portsmouth ..	29·91	41	40	Z.	0	5	S.E.	o.	0·12	1
Havre	—	48	—	E.N.E.	3	3	S.E.	b.	—	5
Cherbourg ..	29·96	45	—	N.W.	1	5	N.	o.	—	4
Brest	30·03	46	44	N.N.W.	4	7	N.N.W.	r. o.	0·05	2
L'Orient ..	30·00	45	45	W.N.W.	5	7	W.N.W.	r. c.	0·05	3
Rochefort ..	29·93	45	43	N.W.	5	5	N.W.	c.	0·01	2
Limoges ..	29·91	41	—	W.	2	3	S.W.	o.	—	—
Montauban ..	29·89	44	—	S.W.	3	3	S.W.	b.	—	—
Biarritz	30·01	46	44	W.	7	—	—	t.	0·59	4
Bilbao	30·01	48	—	N.W.	4	—	—	r.	—	4
Corunna ..	30·36?	52	—	N.W.	2	—	—	b.	—	5
Barcelona ..	29·75	48	—	W.	5	—	—	b.	—	2
Perpignan ..	29·83	46	—	N.W.	6	5	W.N.W.	c.	—	—
Cette	29·72	50	—	N.W.	5	3	N.W.	b. c.	—	0
Lyons	29·88	43	—	E.	3	—	—	o.	—	—
Marseilles ..	29·68	45	—	N.	2	4	N.W.	o.	—	0
Toulon	29·61	41	39	N.N.E.	1	7	W.N.W.	f. o.	—	4
Berne	29·86	32	—	N.E.	1	1	N.E.	b.	—	—
Leghorn ..	29·63	50	—	N.E.	2	—	—	c.	—	0
Rome	29·59	41	—	N.W.	—	—	—	b.	—	0

March 18, 1869.—8 a.m.—*continued.*

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Naples	29·64	46	—	E.	3	6	S.W.	b. c.	—	0
Palermo ..	29·52	48	—	S.W.	2	3	W.S.W.	o.	—	—
Lesina	29·55	51	—	N.	1	—	—	c.	—	—
Trieste	—	52	—	Z.	0	—	—	b.	—	0
Vienna	29·76	39	—	W.N.W.	2	2	N.W.	b.	—	—
2 p.m.										
Aberdeen ..	29·53	41	39	S.	1	—	—	c.	—	—
Scarborough ..	29·72	47	44	W.S.W.	3	—	—	o.	—	2
Stonyhurst ..	29·75	44	43	W.S.W.	4	—	—	r. o.	—	—
Greencastle ..	29·74	46	43	W.N.W.	4	—	—	r. c.	—	—
Valentia ..	30·04	49	46	N.W.	5	—	—	r. c.	—	3
Falmouth ..	30·00	52	49	N.W.	4	—	—	b.	—	2
Kew	29·90	47	44	W.S.W.	2	—	—	m. o. c.	—	—
Paris	29·96	51	51	S.W.	3	—	—	m. f.	—	—
Rochefort ..	30·08	50	48	N.W.	5	—	—	o.	—	2

March 19, 1869.—8 a.m.

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Haparanda ..	30·00	32	—	S.E.	4	—	—	o.	—	—
Petersburg ..	30·15	21	—	S.	3	—	—	b.	—	—
Riga	29·96	33	—	S.E.	3	—	—	b.	—	—
Hernosand ..	29·86	34	—	S.	1	—	—	o.	—	—
Stockholm ..	29·90	29	—	E.S.E.	2	—	—	o.	—	—
Skudesnæs ..	29·61	37	—	E.S.E.	2	2	E.S.E.	o.	—	2
Groningen ..	29·81	38	—	S.W.	1	—	—	b. c.	—	—
Leipzic	29·96	38	—	S.W.	2	—	—	o.	—	—
Helder	29·83	41	—	W.	4	—	—	—	—	—
Brussels ..	29·95	46	—	S.W.	3	—	—	c.	—	—
Strasburg ..	30·01	45	—	S.W.	3	1	W.	o.	—	—
Paris	30·02	46	—	S.W.	3	2	W.N.W.	o.	...	—
Cape Gris Nez	29·88	43	41	W.S.W.	5	4	W.N.W.	c. o.	...	3
Kew	29·87	43	42	S.W.	2	3	S.W.	r. b. o.	0·07	—
Yarmouth ..	29·86	37	36	S.W.	2	4	S.S.W.	r. m.	0·11	2
Scarborough ..	29·76	39	37	W.S.W.	2	3	S.W.	o. c. b.	...	2
Shields	29·71	39	36	N.W.	2	2	N.W.	c.	...	3
Aberdeen ..	29·61	38	35	S.	1	1	S.S.E.	o. b.	0·03	1
Nairn	29·58	39	36	S.W.	2	1	N.N.W.	c. o. b.	0·13	1
Glasgow ..	29·69	39	37	S.S.W.	1	7	W.N.W.	o.	0·13	—
Ardrossan ..	29·66	42	40	S.W.	3	9	N.W.	c. o.	0·13	3
Stonyhurst ..	29·76	36	34	S.E.	1	4	W.	c. o. r.	0·07	—
Holyhead ..	29·65	44	42	S.S.E.	5	5	S.W.	c. r.	0·12	—
Greencastle ..	29·63	40	39	N.W.	1	7	W.N.W.	c. r.	0·07	—

March 19, 1869.—8 a.m.—*continued.*

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Valentia ..	29·57	44	43	N.W.	10	10	N.W.	c. r.	0·63	9
Cape Clear ..	29·44	47	46	W.S.W.	9	2	N.W.	c. o.	0·24	7
Roche's Point	29·42	49	48	W.S.W.	5	5	N.N.W.	b. c.	0·20	3
Pembroke ..	29·76	48	48	S.W.	7	6	W.	c. r.	0·08	4
Falmouth ..	29·77	50	50	S.W.	6	6	N.W.	b. c.	—	4
Plymouth ..	29·79	51	50	S.W.	4	3	W.N.W.	c. r.	0·06	3
Portsmouth ..	29·81	45	44	S.W.	1	4	W.	c. m.	...	1
Havre	29·96	46	—	W.	2	2	W.	o.	—	5
Cherbourg ..	29·94	47	—	S.S.W.	2	2	W.	o.	—	4
Brest	29·99	52	50	W.	5	5	W.S.W.	m.	...	3
L'Orient ..	30·07	50	50	W.S.W.	5	5	W.	c. r.	0·01	4
Rochefort ..	30·16	46	46	N.W.	5	5	N.W.	o.	...	2
Limoges ..	30·16	45	—	W.	3	—	—	r.	—	—
Montauban ..	30·28	48	—	S.S.W.	3	3	S.W.	o.	—	—
Biarritz.. ..	30·28	50	50	W.	4	1	W.N.W.	m. r.	0·08	6
Bilbao	30·31	—	—	N.W.	2	—	—	c.	—	—
Corunna ..	30·43	53	—	N.W.	1	—	—	b. c.	—	2
Oporto	30·41	57	—	S.E.	1	—	—	f.	—	4
Lisbon	30·38	53	—	N.	2	—	—	b.	—	2
Alicant	30·24	61	—	N.E.	1	—	—	b.	—	1
Madrid	30·35	41	—	S.	1	—	—	b.	—	—
Barcelona ..	30·11	52	—	W.	3	—	—	b.	—	1
Perpignan ..	—	54	—	N.W.	6	3	N.W.	b.	—	4
Cette	30·12	50	—	N.W.	5	6	N.W.	b. c.	—	2
Lyons	30·20	44	—	S.W.	3	—	—	o.	—	—
Marseilles ..	30·00	47	—	N.	4	2	N.W.	b.	—	4
Toulon	29·92	45	41	N.W.	4	2	W.N.W.	b.	...	4
Antibes	—	—	—	N.E.	3	5	S.W.	b.	—	0
Berne	30·16	39	—	S.	2	—	N.E.	o.	—	—
Leghorn ..	29·94	49	—	E.	3	3	E.N.E.	b.	—	0
Rome	29·81	46	—	N.E.	2	3	S.W.	b.	—	1
Naples	29·80	50	—	E.N.E.	5	6	S.E.	b. c.	—	4
Palermo ..	29·68	52	—	N.N.E.	3	2	E.N.E.	r.	—	—
Ancona	29·92	48	—	N.N.W.	3	2	W.N.W.	b.	—	4
Lesina	29·81	53	—	N.E.	5	—	—	b. c.	—	1
Trieste	29·98	50	—	Z.	0	—	—	b.	—	—
Vienna	29·94	43	—	W.N.W.	6	—	—	c.	—	—
Constantinople	29·88	46	—	N.	2	0	Z.	o.	—	—
Odessa	29·64	37	—	S.E.	6	—	—	o. r.	—	5
Moscow	30·25	16	—	S.	3	—	—	o.	—	—

2 p.m.

Aberdeen ..	29·56	45	42	S.S.W.	1	—	—	b.	—	—
Scarborough ..	29·59	42	39	S.	3	—	—	c. r.	—	3
Stonyhurst ..	29·49	35	34	E.N.E.	3	—	—	r. s.	—	—
Valentia ..	29·89	43	42	N.N.W.	10	—	—	h. c.	—	9
Falmouth ..	29·45	41	40	W.N.W.	11	—	—	r.	—	7
Kew	29·48	49	48	S.	3	—	—	r. o.	—	—
Paris	29·79	46	—	S.	6	—	—	o.	—	—
Rochefort ..	29·99	54	52	W.S.W.	5	—	—	o.	—	2

MARCH 20, 1869.—8 A.M.

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Haparanda ..	29·72	11	—	S.E.	3	—	—	o.	—	—
Petersburg ..	29·85	32	—	S.E.	3	3	E.S.E.	s.	—	—
Riga	29·78	35	—	S.E.	3	—	—	o.	—	—
Hernosand ..	29·67	31	—	S.S.W.	2	—	—	c. o.	—	—
Stockholm ..	29·72	34	—	E.	2	3	E.S.E.	s.	—	—
Christiansund	29·98	37	—	E.S.E.	2	—	—	o.	—	2
Skudesnæs ..	29·60	37	—	E.	2	2	E.S.E.	o.	—	2
Groningen ..	29·42	41	—	E.	1	—	—	o.	—	—
Leipsic	29·59	41	—	S.	3	—	—	o.	—	—
Helder	29·37	42	—	E.	7	—	—	—	—	—
Brussels ..	29·32	46	—	E.S.E.	1	—	—	o. r.	—	—
Strasburg ..	29·45	46	—	S.	3	5	S.W.	c.	—	—
Paris	29·33	39	—	W.N.W.	7	7	S.W.	o. r.	0·41	—
Cape Gris Nez	29·34	36	36	N.	11	7	S.W.	r.	0·09	7
Kew	29·52	37	36	N.	7	9	N.N.W.	r. o.	0·23	—
Yarmouth ..	29·45	37	37	N.N.E.	9	9	S.E.	r.	0·72	6
Scarborough ..	29·62	39	38	N.	4	6	E.N.E.	r. c.	0·28	4
Shields	29·67	37	35	N.W.	2	2	N.W.	c.	...	2
Aberdeen ..	29·63	40	37	N.W.	1	1	S.	b.	...	1
Nairn	29·66	38	36	S.W.	2	5	S.W.	b. o. c.	0·03	1
Glasgow ..	29·71	38	35	W.S.W.	2	4	N.W.	b. c.	...	—
Ardrossan ..	29·73	40	38	N.W.	2	7	W.S.W.	c.	0·15	2
Stonyhurst ..	29·71	37	34	N.N.W.	3	4	N.N.E.	c. h. s.	0·35	—
Holyhead ..	29·80	42	39	N.N.W.	8	9	E.N.E.	r. c.	0·94	—
Greencastle ..	29·84	41	39	N.N.W.	4	7	N.W.	r. h. c.	0·19	—
Valentia ..	30·16	43	40	N.N.W.	8	11	N.N.W.	h. l. c.	0·15	8
Cape Clear ..	30·07	39	37	N.	6	8	N.W.	c.	0·07	4
Roche's Point	30·01	41	39	N.N.W.	6	9	N.N.W.	o. c.	0·15	4
Pembroke ..	29·84	41	38	N.N.W.	8	9	N.N.W.	c.	0·17	4
Falmouth ..	29·89	43	38	N.N.W.	10	11	N.W.	h. c.	—	6
Plymouth ..	29·83	42	40	N.N.W.	7	10	N.N.W.	r. b.	0·64	6
Portsmouth ..	29·57	41	38	N.	8	10	N.	r. o.	0·34	7
Havre	29·45	41	—	N.N.W.	11	6	S.W.	p.	—	9
Cherbourg ..	29·68	43	—	N.W.	9	6	S.W.	o.	—	7
Brest	29·91	39	37	N.N.W.	8	9	W.S.W.	r. o.	0·06	3
L'Orient ..	29·84	43	43	N.N.W.	9	8	N.W.	r. c.	0·05	6
Rochefort ..	29·82	46	41	N.W.	9	5	W.S.W.	o. c.	0·04	6
Limoges ..	29·64	41	—	W.S.W.	6	3	S.W.	r.	—	—
Montauban ..	29·77	37	—	N.W.	3	3	S.W.	b.	—	—
Biarritz	29·96	50	48	W.	5	—	—	r.	0·20	5
Bilbao	30·00	45	—	N.W.	6	—	—	t. l. h.	—	4
Corunna ..	30·35	52	—	N.E.	5	3	N.W.	c.	—	4
Lisbon	30·35	52	—	N.	7	—	—	b. c.	—	3
Madrid	30·12	46	—	N.W.	4	—	—	c.	—	—
Perpignan ..	29·82	48	—	N.W.	7	4	N.W.	b. c.	—	—
Cette	29·76	50	—	N.W.	6	4	N.W.	b. c.	—	3
Lyons	29·65	43	—	S.W.	6	2	S.	r.	—	—
Marseilles ..	29·67	45	—	W.	5	5	N.W.	o.	—	5
Toulon	29·69	45	43	W.N.W.	6	8	W.N.W.	f.	...	5
Antibes	—	—	—	W.	7	3	S.W.	o.	—	5

March 20, 1869.—8 a.m.—*continued.*

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Berne	29·67		—	W.	3	1	S.W.	r.	—	—
Leghorn ..	29·62	50	—	E.	2	2	N.E.	o.	—	0
Rome	29·68	42	—	N.W.	—	—	—	b. c.	—	3
Naples	29·74	48	—	W.N.W.	2	2	E.	c.	—	1
Palermo ..	29·73	53	—	S.W.	3	2	W.N.W.	o.	—	4
Ancona	29·66	49	—	E.S.E.	—	2	W.N.W.	b.	—	0
Trieste	29·70	51	—	S.E.	1	—	—	o.	—	0
Vienna	29·64	36	—	W.	1	5	W.	f.	—	—
Odessa	29·64	39	—	S.E.	4	—	—	o.	—	5
Moscow	30·47	18	—	Z.	—	—	—	—	—	—

2 p.m.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
Aberdeen ..	29·61	44	40	N.N.W.	5	—	—	c.	—	—
Scarborough ..	29·68	44	42	N.N.E.	5	—	—	c.	—	4
Stonyhurst ..	29·70	45	39	N.	4	—	—	c.	—	—
Valentia ..	30·21	47	43	N.N.W.	8	—	—	h. c.	—	7
Falmouth ..	29·92	46	40	N.N.W.	8	—	—	c.	—	5
Kew	29·61	41	40	N.	6	—	—	r.	—	—
Paris	29·38	39	—	W.N.W.	7	—	—	r. o.	—	—

March 21, 1869.—8 a.m.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Haparanda ..	29·92	39	—	S.	2	—	—	o.	—	—
Petersburg ..	29·86	34	—	Z.	0	—	—	c.	—	—
Riga	29·78	36	—	N.W.	2	—	—	o.	—	—
Hernosand ..	29·85	—	—	Z.	0	—	—	o.	—	—
Stockholm ..	29·93	32	—	N.N.E.	3	2	E.S.E.	o. f.	—	—
Christiansund	29·98	36	—	S.E.	3	—	—	c.	—	4
Skudesnæs ..	29·94	37	—	Z.	0	2	E.S.E.	c.	—	2
Groningen ..	29·65	41	—	N.E.	2	—	—	o.	—	—
Leipzic	29·63	36	—	E.N.E.	3	—	—	o.	—	—
Helder	29·64	41	—	N.E.	6	—	—	o.	—	—
Brussels ..	29·58	43	—	N.E.	—	—	—	r.	—	—
Strasburg ..	29·42	41	—	S.	1	6	S.	r.	—	—
Paris	29·53	43	—	N.E.	2	8	W.N.W.	r. o. c.	—	—
Cape Gris Nez	29·61	41	41	N.E.	9	11	N.	r. o.	0·05	7
Kew	29·73	42	40	N.N.E.	7	9	N.	r. s. o.	0·44	—
Yarmouth ..	29·76	40	40	N.	6	10	N.	r.	1·53	7
Scarborough ..	29·89	41	40	N.E.	7	6	N.E.	c. r.	0·16	5

MARCH 21, 1869.—8 A.M.—*continued.*

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Shields	30·00	41	40	N.E.	5	6	N.W.	c. o.	...	4
Aberdeen ..	30·05	40	39	N.	2	4	N.W.	r. c.	0·07	3
Nairn	30·12	39	38	N.E.	1	2	N.N.W.	b. r. o.	0·05	2
Glasgow ..	30·07	41	36	N.N.E.	5	4	N.	b. c.	...	—
Ardrossan ..	30·12	44	42	N.N.E.	3	4	N.N.W.	c. b.	—	1
Stonyhurst ..	29·94	38	35	N.N.E.	4	3	N.	b. c.	0·01	—
Holyhead ..	30·03	43	39	N.N.W.	8	8	N.N.W.	c.	...	—
Greencastle ..	30·19	44	41	N.N.E.	6	7	N.N.W.	h. r. c.	0·05	—
Valentia ..	30·17	43	40	N.N.E.	3	9	N.N.W.	b. c.	...	3
Cape Clear ..	30·14	45	42	N.E.	5	3	N.E.	c.	...	3
Roche's Point	30·06	43	40	N.	7	8	N.N.W.	c.	...	4
Pembroke ..	29·95	42	40	N.	6	8	N.N.W.	c.	0·07	2
Falmouth ..	29·93	42	40	N.	7	9	N.N.W.	r. c.	—	4
Plymouth ..	29·91	43	41	N.	4	8	N.N.W.	c. b.	0·04	4
Portsmouth ..	29·78	42	40	N.E.	6	8	N.	r. o.	0·47	6
Havre	29·57	45	—	N.E.	9	8	N.	r.	—	7
Cherbourg ..	29·73	41	—	N.	9	8	N.	r.	—	7
Brest	29·87	43	39	N.	5	8	N.N.W.	o.	0·05	3
L'Orient ..	29·77	43	41	N.N.W.	8	9	N.N.W.	r. c.	0·04	5
Rochefort ..	29·63	43	41	N.	9	9	N.W.	c.	—	6
Limoges ..	29·54	37	—	S.W.	2	6	N.W.	r.	—	—
Montauban ..	29·65	45	—	N.W.	2	6	N.W.	o.	—	—
Biarritz.. ..	29·74	41	39	N.W.	9	—	—	t.	0·43	7
Corunna ..	30·35?	51	—	N.E.	9	—	—	o.	—	6
Lisbon	30·34	53	—	N.	7	—	—	b. c.	—	3
Alicant	30·00	66	—	N.W.	3	—	—	c.	—	2
Barcelona ..	29·53	43	—	W.	7	—	—	b. c.	—	—
Perpignan ..	29·53	43	—	N.W.	7	7	N.W.	o.	—	—
Cette	29·72?	50	—	N.W.	6	6	N.W.	b. c.	—	1
Lyons	29·49	40	—	S.W.	3	—	—	r.	—	—
Toulon	29·31	39	35	N.W.	7	9	N.W.	c.	—	6
Berne	29·52	33	—	E.	1	3	W.	s.	—	—
Leghorn ..	29·38	42	—	—	—	4	W.S.W.	o.	—	0
Rome	29·35	44	—	S.	5	—	—	r. s.	—	4
Naples	29·46	46	—	N.E.	4	9	S.W.	c.	—	3
Palermo ..	29·46	48	—	W.S.W.	4	3	W.S.W.	o.	—	2
Ancona	29·30	47	—	W.	2	3	S.E.	o.	—	4
Lesina	29·32	51	—	S.	8	—	—	r. t.	—	7
Trieste	29·37	49	—	N.E.	7	—	—	o.	—	5
Vienna	29·53	41	—	S.E.	2	2	E.	o. f.	—	—

2 P.M.

Aberdeen ..	**30·13**	**43**	**40**	**N.N.E.**	**3**	—	—	**r. c.**	—	—
Stonyhurst ..	**30·02**	**43**	**40**	**N.E.**	**4**	—	—	**b. c.**	—	—
Valentia ..	**30·20**	**50**	**45**	**N.N.E.**	**4**	—	—	**c.**	—	—
Falmouth ..	**29·96**	**45**	**40**	**N.**	**7**	—	—	**c.**	—	—
Kew	**29·82**	**41**	**38**	**N.N.E.**	**6**	—	—	**c. r.**	—	—

MARCH 22, 1869.—8 A.M.

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Haparanda ..	30·29	6	—	N.	3	—	—	b.	—	—
Riga	29·96	34	—	N.E.	3	—	—	o.	—	—
Hernosand ..	30·25	28	—	N.E.	3	—	—	o.	—	—
Christiansund	30·24	31	—	Z.	0	—	—	b.	—	—
Skudesnæs ..	30·22	35	—	N.N.W.	2	—	—	b.	—	2
Groningen ..	30·07	41	—	N.E.	3	—	—	o.	—	—
Leipzic	29·66	38	—	N.	1	—	—	r.	—	—
Helder	30·01	39	—	N.E.	6	—	—	—	—	—
Strasburg ..	29·63	42	—	N.	6	—	—	o. c.	—	—
Paris	29·87	43	—	N.N.E.	2	6	N.N.E.	o.	—	—
Kew	30·07	41	39	N.E.	5	8	N.N.E.	r. o.	0·17	—
Scarborough ..	30·21	42	40	N.N.E.	5	7	N.E.	c.	0·03	4
Nairn	30·34	40	39	W.	1	2	N.E.	o.	0·05	2
Greencastle ..	30·37	44	42	S.W.	1	6	N.N.E.	c.	...	—
Valentia ..	30·39	44	40	N.	2	4	N.W.	c.	...	3
Penzance ..	30·13	43	40	N.N.E.	7	10	N.W.	c.	...	4
Brest	30·03	45	41	N.E.	5	7	N.	o. f.	0·03	2
Rochefort ..	29·69	45	43	N.	9	9	N.	o.	0·03	6
Toulon	29·51	41	—	N.E.	5	8	W.N.W.	c. r.	0·02	7
Berne	29·63	34	—	E.	2	1	S.	o.	—	—
Rome	29·48	43	—	E.N.E.	—	—	—	—	—	—
Naples	29·55	45	—	N.W.	4	—	—	b. c.	—	5
Ancona	29·48	48	—	N.	2	3	E.	o.	—	—

INSTANCE III.

August 11, 12, 1868.

Both the preceding examples occurred at a period when, previous to the establishment of the circulation, the atmosphere was much colder in the East than in the West. The slope of the isothermals across the West of Europe was nearly from N.N.W. to S.S.E. In accordance with this condition the heaviest precipitation took place (with local exceptions) in the S. and in the S.S.W. currents during the transit of the systems across the British Isles, and the development extended from W. and W.N.W. to E. and E.S.E.

The present instance has been selected simply as occurring under very diverse conditions as regards the distribution of temperature; the temperature of the N.W. coasts of the British Isles, immediately previous to the development, being depressed as compared with that of the S.E., and isothermals across Western Europe generally running nearly N.E. to S.W.

This system was the first of a series in preference to the other members of which it has been chosen for description, partly because its anemological conditions were of a simpler character, and partly because its point of primary formation lay more completely within the region of observation. It also presents us with a much fairer type of our average summer depressions than the otherwise more interesting (because more intense and destructive) circulation of August 22nd, in which the series culminated. It has been remarked in a previous chapter that our European systems of retrograde circulation, when attended with equally heavy and extensive precipitation, are yet commonly of far less intensity in the summer than in the winter months; and we sought to trace a connection of this general rule with the fact that the column of precipitating atmosphere appears to be of much greater altitude in the warm than in the cold seasons of the year, and that in consequence the effects of the abstraction of aqueous vapour are not so exclusively experienced in the lowest, and may even be altogether transferred to the higher, atmospheric strata. In the present instance the rainfall was very heavy along the track of the baric minimum, yet the currents drawn into the helix were feeble in force.

During the period preceding the depression several retrograde systems of moderate intensity followed one another in succession on the extreme N.W. of the British

Isles along the prevailing track of the summer depressions to N. and N.N.E. On the 8th a very widely expanded depression existed to the Northward of Great Britain, while an area of direct circulation was located over France. Pressures now gradually tended to uniformity, a condition almost absolutely attained on the afternoon of the 10th, when a difference of only ·04 was observable in the barometric readings at Nairn, Greencastle, Valentia, Penzance, Yarmouth, and Paris. This condition was accompanied with a somewhat damp and sultry atmosphere, and with considerable electric disturbance. Numerous local thunder-showers occurred on the 10th, and on the following night a very extensive bank of Nimbus became developed over the South of Ireland and the entrance of St. George's Channel. Around this region the surface currents, which had hitherto been extremely variable, now began slowly to circulate, and at 8 A.M. of the 11th, as shown in Plate XV., the system was tolerably well defined, though the intensity of the depression was extremely slight, and the movement of the atmosphere correspondingly slow. The baric minimum, about 29·53, was now between Dublin and Pembroke: gradients were everywhere low, but were slightly steeper in the N. and W. than in the E. N. East breezes were now experienced in Scotland, drawing to N. and N.W. on the West of Ireland: on the French coast a S.W. wind was felt, drawing to S.E. in England.

Referring to the temperature returns for this morning and for the several preceding days, we observe that in Western and Central France temperature was no higher than in the S.E. counties of England, in Holland, and in Northern Germany, there being few degrees of difference between Groningen, Helder, Dunkirk, Yar-

mouth, London, &c., and the more Southern stations, such as Strasburg, Mézières, Paris, Havre, Rochefort, and Limoges. Consequently the current now established from the West coast of France towards the North Sea undergoes in its progress scarcely any diminution of temperature, and does not precipitate. But in passing from the South coast of the German Ocean to the Northern portions of the British Isles, the atmosphere here set in motion suffers a reduction of temperature amounting to between 10° and 15°, and, the lowest temperatures being in the N.W., the water-vapour is most largely precipitated to the immediate North of the baric minimum; the Easterly are the precipitating, and the Westerly the evaporating winds; and the system is developed in a Poleward direction.

Rainfall reports of the 10th and 11th show that in the South of Ireland, and in the Southern, S. Midland, and Eastern counties of England, the fall amounted in only a very few localities to 0·50 in. In the Western counties of Ireland the fall was still less, but on the Eastern coast, from Wicklow to Antrim, falls of above 0·50 occurred on the 11th; at Bray the fall was 1·10; at Greencastle, on the North coast, upwards of 1·50 fell. On the immediate East of the baric minimum the fall was very variable, thunderstorms being prevalent. In Wales and the West Midlands upwards of half an inch fell in many localities, while others were rainless. In Yorkshire and Lancashire the falls were generally between 0·50 and 1·00, while at some points, as at Stonyhurst, upwards of an inch fell. The same may be said of the extreme Northern counties of England. It was, however, in Scotland that precipitation on the 11th was the heaviest and most extensive. In Islay, 1·30 fell; at Ardross, 2·40; at Aberdeen, 2·58;

Bræmar, 1·00; Nairn, 1·36; Fort William, 1·40; Portree, 1·12; while from Sutherlandshire violent rain is reported, and at Sandwich, Orkney, the fall was 1·28. In short, the rainfall appears to have averaged upwards of one inch over the whole of the extreme North of Great Britain, in the Easterly current.

The centre of depression which existed over the Irish Sea at 8 A.M. of the 11th, with barometers about 29·53, passed the Moray Firth shortly after midnight, with a minimum of 29·30, having progressed towards the North at a rate of about 18 geographical miles per hour. The subsequent wind and pressure changes on the Scotch and Norwegian coasts show its further progress to have been towards N.N.E. In Scotland pressures rose briskly during the 12th with a current from W.N.W.; while at Christiansund and Skudesnæs they diminished with equal rapidity, the E.S.E. current veering to S., rising subsequently as the wind veered to S.W. on the night of the 12th.

Plate XVI. represents the anemological conditions at 8 A.M. of the 12th. An extensive area of pressures below 29·50 now existed over the North Sea. The currents of its Eastern arc of circulation were felt over Germany, the Baltic, Scandinavia, and the Gulf of Bothnia. Those of the S. Western arc were complicated and interrupted by the approach of a totally new system of depression, the region of whose development appears to have lain off the West coast of Spain.

This second system reached the S. coast of Ireland on the night of the 12th, in a stage of development precisely similar to that in which the former system passed over Scotland, but its intensity was much greater. It traversed Great Britain to the N.E. on the 13th, and was dissipated on the 14th. It was succeeded by a third

on the 15th. A fourth, developed in France with violent thunder and hail on the 16th and 17th, passed slowly to N.N.W. into England, where it became slowly dissipated on the 18th. This was followed by a brief restoration of equilibrium, after which a violent cyclonic storm traversed the British Isles to N.E. on the 22nd.

Plate XVII. represents the track of the baric minimum in the disturbance of the 11th–12th, the expanse of the 29·50 isobarics, and the inclination of the mean isothermals immediately previous to the development of the system of circulation.

METEOROLOGICAL REPORTS.

AUGUST 10, 1868.—8 A.M.

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Nairn	29·89	60	55	W.	2	6	W.	c.	0·15	1
Aberdeen ..	29·95	56	54	S.	1	4	S.W.	b.	...	1
Shields	30·01	62	56	W.S.W.	2	2	W.S.W.	c. m.	...	2
Yarmouth ..	30·04	69	64	E.S.E.	2	4	S.S.E.	c.	...	2
Helder	30·03	68	—	N.E.	2	—	—	—	—	2
Skudesnæs ..	30·03	64	—	S.S.E.	2	5	—	b.	—	2
Greencastle ..	29·95	59	57	W.S.W.	1	4	S.W.	r. c.	0·07	—
Holyhead ..	30·03	61	59	S.S.W.	2	4	S.S.W.	c.	...	—
Valentia ..	29·96	62	58	S.S.W.	3	6	W.	b. c.	...	2
Cape Clear ..	29·92?	65	64	S.E.	2	3	S.W.	c.	0·05	1
Penzance ..	30·01	62	60	Z.	0	3	S.W.	c.	...	2
Portsmouth ..	29·96	66	61	E.	1	1	W.S.W.	c.	...	1
London	30·01	67	62	E.	4	2	W.	o. l. c.	...	—
Cape Gris Nez	29·97	66	62	N.E.	3	4	N.W.	c.	0·35	1
Brussels ..	29·98	66	—	N.E.	1	—	—	t. o.	—	—
Strasburg ..	—	75	—	W.N.W.	3	—	—	r.	—	—
Paris	29·99	73	—	S.	2	—	—	o.	—	—
Brest	29·96	63	58	E.	4	4	E.	b.	...	2
Rochefort ..	29·99	72	68	N.	4	4	N.	c.	...	1
Biarritz	29·89	79	75	W.	1	—	—	m.	...	6
Corunna ..	29·99	72	—	N.W.	3	—	—	m.	...	4
Oporto	30·07	69	—	W.	3	—	—	o.	—	2
Lisbon	30·08	70	—	N.N.W.	3	—	—	b.	—	2
Alicant	30·08	89	—	E.	4	—	—	b.	—	1
Toulon	30·13	82	80	S.E.	1	1	S.	b. c.	...	1
Lyons	30·16	75	—	S.E.	3	—	—	c.	—	—

August 10, 1868.—2 p.m.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Nairn	29·91	65	58	W.	3	—	—	c.	—	2
Scarborough ..	29·99	65	60	S.S.E.	2	—	—	c.	—	2
Valentia ..	29·94	64	62	W.S.W.	2	—	—	r. c.	—	1
Greencastle ..	29·91	63	60	E.N.E.	2	—	—	c.	—	—
Penzance ..	29·93	69	66	S.	3	—	—	c. b.	—	2
London	29·92	75	68	E.S.E.	2	—	—	b. c.	—	—
Paris	29·92	84	—	S.E.	2	—	—	o.	—	—
Rochefort ..	29·92	79	74	N.W.	4	—	—	b.	—	1

August 11, 1868.—8 a.m.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Haparanda ..	29·82	59	—	S.W.	2	—	—	o.	—	—
Petersburg ..	29·99	62	—	W.	3	—	—	c.	—	—
Riga	30·03	60		S.	3	—	—	b.	—	—
Hernosand ..	29·74	59		Z.	0	—	—	b. c.	—	—
Stockholm ..	29·93	64		S.W.	2	2	W.S.W.	o.	—	—
Christiansund	29·81	52		S.W.	5	—	—	b. c.	—	6
Skudesnæs ..	29·92	64		Z.	0	5	S.S.W.	c.	—	2
Groningen ..	29·82	69		S.E.	3	—	—	b.	—	—
Helder	29·77	74		S.S.E.	3	—	—	—	—	2
Brussels ..	29·76	71		E.S.E.	1	—	—	b.	—	—
Strasburg ..	29·94	75		W.	1	1	W.	c.	—	—
Paris	29·95	71		S.E.	2	2	S.S.E.	o.	—	—
Cape Gris Nez	29·68	68	66	S.S.E.	4	4	N.	c.	...	2
London	29·65	73	68	S.W.	4	4	E.	b. o.	...	—
Yarmouth ..	29·66	70	67	S.E.	3	4	E.N.E.	c.	...	3
Scarborough ..	29·71	63	61	E.S.E.	1	2	S.S.E.	c. o.	0·01	3
Shields	29·71	63	61	S.E.	2	0	Z.	r. o.	0·06	2
Aberdeen ..	29·82	57	56	N.E.	1	2	N.	r.	0·07	1
Nairn	29·84	55	54	N.E.	2	3	W.	c. o.	...	2
Ardrossan ..	29·70	57	56	N.E.	4	1	S.	c. r.	0·21	2
Holyhead ..	29·55	61	60	S.S.E.	1	2	S.S.W.	c. o.	0·27	—
Greencastle ..	29·68	57	55	E.N.E.	1	2	N.	c. r.	0·28	—
Valentia ..	29·72	56	54	N.	5	4	W.	c. r.	0·46	5
Cape Clear ..	29·66	58	57	S.W.	3	2	S.W.	o. r.	0·32	2
Roche's Point	29·66	56	56	N.N.E.	2	3	S.	r. c.	0·55	1
Penzance ..	29·57	65	64	S.S.W.	1	3	S.	b. o. r.	...	3
Plymouth ..	29·61	65	64	S.	3	3	S.	b. o.	...	3
Portsmouth ..	29·64	68	65	W.S.W.	3	2	S.S.W.	b. r.	...	2
Havre	29·74	72		E.	3	5	S.E.	o.	—	4
Cherbourg ..	29·72	66		S.S.E.	5	2	N.E.	r.	—	5
Brest	29·64	63	61	W.S.W.	4	4	W.S.W.	o.	...	2
L'Orient ..	29·69	64	62	S.W.	4	3	W.	c. t.	0·32	3
Rochefort ..	29·79	68	66	W.	5	4	N.W.	b. r. t.	—	2

AUGUST 11, 1868.—8 A.M.—*continued.*

STATION.	Baro-meter.	Thermom.		Wind.		Extreme Wind.		Weather.	Rain-fall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Limoges ..	29·79	71	—	S.W.	3	3	S.	b. c.	—	—
Montauban ..	29·81	77	—	S.W.	3	2	E.	b.	—	—
Biarritz	29·80	72	68	W.S.W.	8	—	—	r.	0·35	4
Corunna ..	29·90	81	—	N.W.	3	—	—	c.	—	2
Perpignan ..	29·91	75	—	E.S.E.	3	2	W.S.W.	b. c.	—	3
Cette	?	82	—	E.N.E.	4	2	S.W.	c.	—	3
Lyons	29·82	77	—	S.E.	3	—	—	b.	—	—
Marseilles ..	29·96	78	—	N.E.	—	—	—	—	—	—
Toulon	29·93	79	79	E.S.E.	1	2	S.S.E.	b.	...	1
Antibes	?	?	—	N.N.E.	2	2	S.S.E.	c.	—	0
Berne	30·05	65	—	E.S.E.	2	—	—	b.	—	—
Leghorn ..	30·01	81	—	E.N.E.	2	—	—	b.	—	0
Rome	29·99	73	—	N.W.	1	—	—	b.	—	0
Naples	30·03	72	—	E.	3	2	S.W.	b.	—	0
Palermo ..	29·95	76	—	W.S.W.	2	2	N.E.	b.	—	2
Ancona	29·90	73	—	N.N.W.	2	2	N.W.	b.	—	0
Constantinople	29·92	75	—	N.E.	6	7	N.E.	b.	—	—
Odessa	30·04	73	—	N.	2	—	—	b.	—	0

2 P.M.

Nairn	29·71	56	56	E.N.E.	2	—	—	r.	—	—
Scarborough ..	29·60	61	60	E.S.E.	3	—	—	t. l. r.	—	3
Valentia ..	29·72	60	55	N.	5	—	—	r. c.	—	5
Penzance ..	29·68	65	62	N.W.	6	—	—	o. c.	—	4
London	29·57	72	64	W.S.W.	3	—	—	o.	—	—
Paris	29·96	73	—	W.	5	—	—	o. r.	—	—
Corunna ..	29·95	74	—	N.W.	3	—	—	c.	—	3

AUGUST 12, 1868.—8 A.M.

STATION.	Baro-meter.	Thermom.		Wind.		Extreme Wind.		Weather.	Rain-fall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Riga	29·80	70	—	S.E.	4	—	—	o.	—	—
Christiansund	29·59	59	—	E.S.E.	5	—	—	o.	—	3
Skudesnæs ..	29·41	67	—	E.	3	2	E.N.E.	o.	—	3
Groningen ..	29·65	66	—	S.	4	—	—	o.	—	—
Leipzic	29·90	73	—	W.	2	—	—	t. c.	—	—
Helder	29·67	68	—	W.	6	—	—	—	—	5
Brussels ..	29·81	64	—	S.W.	6	—	—	t. c.	—	—
Strasburg ..	29·92	74	—	W.	3	1	N.W.	c.	—	—
Paris	29·85	62	—	S.W.	2	2	W.S.W.	c.	—	—
Cape Gris Nez	29·74	63	59	W.	8	9	W.	r. c.	0·12	6
London	29·71	61	55	S.W.	2	6	S.W.	o. c.	0·03	—

AUGUST 12, 1868.—8 A.M.—*continued.*

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Yarmouth ..	29·68	60	57	W.N.W.	2	4	E.S.E.	r. b.	0·11	2
Scarborough..	29·54	60	57	S.W.	4	3	E.S.E.	t. l. c.	0·62	3
Shields	29·47	61	56	W.N.W.	6	4	W.	r. c.	0·43	2
Leith	29·36	58	56	W.	4	2	E.	r. o.	0·41	—
Aberdeen ..	29·33	54	53	W.	1	3	N.E.	r. o.	2·58	4
Nairn	29·35	55	53	N.W.	2	5	E.N.E.	r. c.	1·36	2
Ardrossan ..	29·44	58	56	W.N.W.	4	5	N.E.	r. o.	2·22	3
Holyhead ..	29·57	60	57	W.S.W.	3	4	W.	o. r. c.	0·12	—
Greencastle ..	29·55	55	54	N.	2	4	N.	r. o.	1·40	—
Valentia ..	29·63	56	53	N.N.W.	2	5	N.	r. c.	...	1
Cape Clear ..	29·56	52	51	N.E.	4	3	N.W.	c. r.	0·53	3
Roche's Point	29·58	52	52	N.N.W.	3	3	N.N.W.	c. m.	...	1
Penzance ..	29·66	63	60	S.	6	7	N.W.	o. m. c.	0·02	4
Plymouth ..	29·70	62	60	S.W.	6	7	S.W.	c.	0·18	4
Portsmouth ..	29·76	62	59	W.	2	4	S.W.	r.	0·09	1
Havre	29·80	64	—	S.W.	2	6	S.W.	o.	—	4
Cherbourg ..	29·79	63	—	W.	2	6	S.S.W.	c.	—	4
Brest	29·73	61	57	S.S.E.	4	5	W.	o.	...	2
L'Orient ..	29·74	64	60	S.	5	7	W.S.W.	c.	...	3
Rochefort ..	29·84	66	62	W.N.W.	7	7	W.N.W.	r.	?	2
Limoges ..	29·88	55	—	E.	2	—	—	c.	—	—
Montauban ..	29·89	70	—	N.	2	3	N.W.	b.	—	—
Biarritz.. ..	29·78	66	64	W.	8	—	—	m.	...	4
Bilbao	29·75	69	—	E.	3	—	—	o.	—	1
Corunna ..	29·73	69	—	S.W.	2	2	N.W.	c.	—	2
Cadiz	29·98	72	—	W.	1	—	—	b.	—	7
Madrid	29·88	65	—	S.W.	2	—	—	c.	—	—
Barcelona ..	29·81	81	—	E.	2	—	—	o.	—	1
Perpignan ..	29·90	73	—	W.N.W.	1	—	—	b. c.	—	—
Cette	30·07?	79	—	N.W.	2	5	S.	b. c.	—	0
Lyons	29·96	73	—	N.E.	3	—	—	b.	—	—
Marseilles ..	29·85	75	—	N.E.	1	4	S.W.	b.	—	0
Toulon	29·88	75	75	E.N.E.	1	3	S.S.W.	b. f.	...	4
Antibes.. ..	—	—	—	N.E.	2	2	S.E.	b.	—	0
Berne	30·00	64	—	N.W.	2	—	—	t. l. c.	—	—
Leghorn ..	29·91	76	—	S.W.	2	3	W.	b.	—	0
Naples	29·94	73	—	W.S.W.	3	2	W.S.W.	b. c.	—	1
Ancona	29·76	80	—	E.	2	1	W.S.W.	b.	—	0
Odessa	29·90	74	—	E.	3	—	—	b.	—	4

2 P.M.

Nairn	29·51	57	54	N.W.	2	—	—	c. o.	—	3
Scarborough..	29·63	68	59	W.S.W.	2	—	—	c.	—	3
Greencastle ..	29·64	57	55	N.	2	—	—	r. c.	—	—
Valentia ..	29·60	52	55	N.E.	4	—	—	r. c.	—	4
Penzance ..	29·56	63	61	S.S.E.	7	—	—	r. c.	—	5
London	29·71	69	60	S.W.	2	—	—	c.	—	—
Rochefort ..	29·74	82	68	S.	3	—	—	b.	—	1

AUGUST 13, 1868.—8 A.M.

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Skudesnæs ..	29·81	59	—	S.W.	2	5	S.	c.	—	3
Helder	29·75	69	—	E.S.E.	4	—	—	—	—	2
Brussels ..	29·67	65	—	N.E.	3	—	—	c.	—	—
Paris	29·64	66	—	N.E.	2	—	—	r.	—	—
London	29·58	66	60	E.S.E.	1	3	S.W.	c. o.	...	—
Scarborough..	29·68	63	60	E.S.E.	2	5	S.W.	c. b.	...	2
Nairn	29·79	53	51	E.N.E.	2	3	N.W.	c. o.	...	1
Ardrossan ..	29·64	54	53	E.N.E.	5	5	N.W.	r.	0·55	3
Greencastle ..	29·55	54	53	N.E.	4	3	N.N.W.	c. r.	0·43	—
Valentia ..	29·56	56	53	N.	7	8	N.N.E.	r. c.	0·16	6
Roche's Point	29·38	53	53	N.	6	8	S.E.	r.	1·15	4
Penzance ..	29·49	60	58	W.	2	7	S.S.E.	r. o.	0·02	3
Brest	29·51	61	57	W.	4	7	S.	o.	...	3
Rochefort ..	29·65	63	61	S.W.	5	3	S.	b. t.	0·75	2
Biarritz.. ..	29·71	64	64	W.	7	—	—	m. r.	0·32	5
Corunna ..	29·89	66	—	S.W.	6	—	—	c.	—	2
Toulon	29·79	73	73	S.	4	3	S.	o. f.	...	5

2 P.M.

Nairn	29·83	54	53	E.N.E.	3	—	—	o.	—	2
Scarborough..	29·61	64	61	S.E.	4	—	—	c. o.	—	4
Greencastle ..	29·51	58	56	E.	4	—	—	r.	—	—
Valentia ..	29·53	56	54	N.	6	—	—	o. r. m.	—	5
Penzance ..	29·52	65	59	W.	6	—	—	c.	—	4
London	29·50	67	62	S.S.E.	2	—	—	r.	—	—

INSTANCE IV.

August 27–29, 1870.

The instance last described occurred at a period in which the relative distribution of temperatures in Europe pretty closely corresponded with that which is commonly prevalent in warm summers. The present example, occurring at a similar season of the year, has again been selected for purposes of contrast.

The declension of temperature which accompanies the

approach of autumn in Europe varies excessively in character in different years. In some it spreads Eastwards from the Atlantic shores, the atmosphere over the interior of the Continent retaining its summer heat after that of the Western coasts has become comparatively cool. In others the case is the reverse; mean temperatures rapidly declining in Russia and Central Europe before the change is greatly felt in the West. These variations, themselves connected with the previous extensive atmospheric currents, and therefore with the distribution of the great centres of high and low pressure, subsequently affect the direction in which local baric depressions progress.

In the early part of August, 1870, numerous depressions traversed the more southern and central districts of the European Continent in a N. Eastward direction. On the 12th, a very extensive area of high pressure, with direct circulation, became established over the Atlantic coast, its central portion lying to the N. West of the British Isles. Up to the 20th, the mean isothermal 60° was generally parallel with the lines of latitude across N. Western Europe, retiring slowly Southwards; but on that day, immediately after a system of depression had passed from the Peninsula N. Eastwards into Switzerland, and when pressures in Eastern Europe were generally low, this isothermal began, under the influence of the extensive polar current, to trend from N.W. to S.E. across the British Isles and the North of France, temperatures in Central Europe and upon the coasts of the North Sea and Baltic rapidly falling much below their average level for the season.

The system of direct currents now became dispersed, and a retrograde circulation, developed in the West of

Scotland on the 21st–22nd, passed to E.S.E. into Central Europe, where it hung for several days and attained large dimensions. On the 26th, barometric returns showed a greater uniformity in N. Western Europe, while the recent distribution of temperatures was unaltered.

Plate XVIII. gives the weather conditions at 8 A.M. of the 27th. A small node of pressure slightly above 30·00 now existed at the entrance of the Channel. To the Eastward of this the polar currents of the great European depression were still feebly felt, while to the North existed a region of almost complete baric uniformity. These conditions are precisely those which experience has shown to be most favourable to the development of a new system of depression, the light S. Westerly breezes on the immediate North of an area of direct currents slowly transferring the water-laden atmosphere from the Atlantic towards a district highly adapted for precipitation, and whose surface had just previously had its temperature depressed by polar winds.

Accordingly about noon of this day, a dense bank of Nimbus overspread the whole of the North of Ireland, in which very heavy precipitation commenced. Shortly afterwards a light Easterly breeze began to be felt at most of the Northern stations of Great Britain; in the Irish Sea a Southerly breeze sprang up; while at Valentia a moderate Westerly current was experienced, freshening as the day advanced. The helix being thus established, the augmentation and spread of the precipitation became very rapid, and the diminution of pressure in the central portion was very great indeed.

In accordance with the distribution of relative temperatures of the atmosphere thus thrown into circulation,

the S.S. Westerly currents, or those existing to the E.S.E. of the depression centre, underwent the most rapid diminution, and the N. Easterly the most rapid augmentation, of temperature. The former therefore parted most rapidly with their water-vapour, and the baric minimum followed in the wake of the greatest precipitation towards E.S.E. The rainfall which had commenced in the North of Ireland in the morning reached Durham, York, and Stonyhurst about 10 P.M. The centre of the helix appears to have crossed the longitude of Greenwich at 7.30 A.M. of the 28th, progressing in this portion of its course at about the rate of thirteen geographical miles per hour.

Plate XIX. exhibits the system at 8 A.M. of the 28th, when the minimum was off the Lincolnshire coast. Pressure in the centre had now fallen as much as ·45 in., while at a distance from the centre the diminution had been much less, especially upon the South side, readings being very little lower in France than on the preceding morning. Consequently the intensity of the depression in this quarter is very great indeed. On the coast of Norway the polar breezes of the previously existing system still held, and the sky continued clear, though pressures had fallen about a tenth, owing to the attraction of the atmosphere towards our Eastern coasts. On the West coast of France pressures had given way to a similar extent, without much alteration of wind or weather.

The system had now attained its secondary stage, in which it left our shores. Continental reports for the succeeding days are very meagre, but its subsequent course appears to have been at first to E. across Denmark, and then to N.E. into Russia, its expansion being accompanied with a diminution of intensity, until it

blended with the extensive area of depression previously existing in the East. The atmospheric changes taking place in the Western arc of the circulation are displayed in Plate XX. for the morning of the 29th. On the 30th the Northerly currents which the system had established over the West of the British Isles being freed from their attraction towards the depression, the influence of the earth's rotation began to assert its supremacy upon them, and N. Easterly breezes consequently prevailed at the entrance of the Channel. On the 31st, however, pressures again gave way in the N.W. under the approach of a new and enormous depression, which subsequently traversed the Northern seas.

The passage of the system above described was accompanied by a very great and extensive precipitation, the data for the examination of which, furnished by the reports of rainfall observers in the British Isles, are unusually satisfactory, because, owing to the dry weather which immediately preceded and followed, and (so to speak) surrounded the transit of the Nimbus, there were few of those independent and supplementary local showers whose occurrence is so frequently an element of complexity in investigations of this character. The following is a summary of the results of the inquiry.

Along the extreme Southern counties of Ireland the fall, which here took place on the evening of the 27th after several days of dry weather, was generally inconsiderable. Nearly ·50 fell at Enniscorthy and at Crookhaven, but at Cork, Waterford, &c., the fall was much less. Points on the West coast show an increasing fall as we advance Northwards, which also began here at an earlier hour. Thus at Valentia the fall on the

27th, including a little which fell before 9 A.M., was ·33, at Killaloe ·86, at Galway 1·09. It was, however, the Northern counties which were situated under the actual focus of the great cloud-bank, and here the fall was generally upwards of an inch. In Donegal about 2 inches fell at Letterkenny, 1 at Strabane, and ·95 at Greencastle; at Antrim the fall was 1·25. Farther to the S. and S.E. again the fall was somewhat less, being not quite an inch in Cavan, Armagh, and Down. Proceeding down the East coast we find the fall diminishing to less than ·50 South of Dublin. At Douglas, Isle of Man, the fall was 1·26.

The Northern border of this Nimbus did not extend beyond lat. 56° in Scotland. In Skye, Tyree, and the coasts of Inverness and Argyle, as well as in the N. Eastern counties, the weather was dry. In Islay there fell ·45, and on the Ayrshire coast upwards of half an inch: a similar fall occurred over the Solway Firth. In the Eastern counties the fall was less on the 27th, but a considerable quantity fell on the morning of the 28th.

Throughout the Northern counties of England the precipitation on the night of the 27th and morning of the 28th seems to have averaged upwards of an inch, being especially heavy in Northumberland, Durham, and the North Riding. On the Yorkshire coast the rainfall (which was here generally upwards of an inch) was nearly equally divided between the S.E. current which preceded and the N.E. which followed the passage of the baric minimum, the polar current precipitating much vapour from the North Sea; but throughout the rest of the country the rainfall was far heaviest in advance of the minimum. In the North of Lancashire the fall (at moderate elevations) was generally between

1 and 1½ inch, in the South about 1 inch, all of which occurred on the night of the 27th. About 1 inch fell in Anglesea, and a similar amount generally in the moderately rainy localities in Northern and Central Wales, and at greater elevations in South Wales and Monmouthshire. Falls of about half an inch took place on the afternoon of the 27th on both the Northern and the Southern coasts of the Bristol Channel, but at some points on the latter this amount was much exceeded, and more than 1 inch fell at Bideford. Along the South coast of England the rainfall was very slight in Devon and Cornwall, East of these counties the amount varied from ¼ to ½ an inch at most localities, increasing generally as we approach the Straits of Dover. Throughout the English Midland and Eastern counties the fall varied generally according to the distance of the locality from the track of the baric minimum, averaging about ½ inch in the more Southern and considerably upwards of this amount in the more Northern districts, a few localities here and there escaping, as usual, with scarcely any rain.

It is not of course possible to calculate, with anything more than a rude approximation to the truth, the total amount of precipitation which occurred during the formation and passage of this system across the British Isles; but we shall probably not be very wide of the mark in concluding, from the mean of the falls occurring in the different districts, that between the morning of the 27th and the evening of the 28th upwards of half an inch of rain was deposited over a space of about 55,000 sq. miles, and upwards of one inch over a further space of 35,000 sq. miles. When it is borne in mind that the rarefaction produced by the abstraction of each cubic inch of water is about equivalent to that

which would result from the abstraction of 860 cubic inches of air, it is not surprising that the deposit of so prodigious a body of water from a single Nimbus should be the occasion of the atmospheric disturbance which we attribute to it.

This system can scarcely be said to have affected the upper-currents. Both immediately before and after, and therefore probably during its passage, Cirrus clouds moved generally with great rapidity from points between N. and W., the currents being dependent upon the old and extensive depression in Eastern Europe, and uninfluenced by the more local disturbance established in the neighbourhood of the earth's surface.

METEOROLOGICAL REPORTS.

AUGUST 26, 1870.—8 A.M.

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Christiansund	?	51	48	N.N.E.	2	6	N.N.E.	b. c.	—	1
Skudesnæs ..	29·76	56	52	N.N.E.	2	2	N.	b.	—	2
Oxo	29·71	52	49	N.N.E.	6	2	E.S.E.	b. c.	—	—
Helder	29·64	55	—	N.W.	3	—	—	—	—	2
Cape Gris Nez	29·77	57	55	W.N.W.	5	4	N.W.	c. o.	...	4
Dover	29·77	58	54	N.N.E.	3	2	N.W.	b.	...	3
London	29·82	56	51	N.N.W.	3	4	N.W.	b. c.	...	—
Yarmouth ..	29·73	52	51	N.N.W.	5	6	W.N.W.	t. c.	0·37	4
Scarborough ..	29·80	55	52	N.N.E.	5	3	N.	c.	0·21	4
Shields	29·85	55	51	N.N.E.	3	3	N.	c.	0·05	1
Leith	29·90	58	51	N.	2	3	N.W.	c. b.	...	—
Aberdeen ..	29·92	53	50	N.N.W.	2	1	N.N.W.	c.	0·05	1
Nairn	29·95	54	50	W.	1	3	W.	o. b.	0·05	1
Wick	29·91	58	53	N.N.W.	3	3	N.W.	c.	...	2
Thurso	29·91	55	52	N.N.E.	3	4	W.N.W.	c. l. b.	0·15	2
Holyhead ..	29·95	55	51	W.N.W.	6	3	W.N.W.	c.	...	—
Greencastle ..	30·02	57	53	N.	2	6	N.N.W.	o. c.	0·08	—
Valentia ..	30·11	61	56	N.N.E.	4	4	N.	b. c.	...	3
Roche's Point	30·04	58	54	N.	5	5	N.	b. o.	...	3
Pembroke ..	29·97	56	51	N.N.W.	6	5	N.N.W.	c.	...	2
Penzance ..	30·02	60	55	N.	5	5	N.	c.	...	4
Plymouth ..	29·98	60	56	N.	3	3	N.	c.	...	1

AUGUST 26, 1870.—8 A.M.—*continued.*

STATION.	Baro-meter.	Thermom.		Wind.		Extreme Wind.		Weather.	Rain-fall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Portsmouth ..	29·85	—	—	N.	5	3	N.	c.	...	4
Brest	30·00	58	56	N.N.W.	3	4	N.N.W.	o. b.	...	2
L'Orient ..	30·03	55	53	N.E.	5	5	N.E.	b. c.	...	2
Rochefort ..	29·99	58	56	N.E.	4	5	N.W.	b.	...	3
Biarritz.. ..	29·76	66	61	S.E.	4	5	N.	c.	...	3
Toulon	29·80	61	52	S.W.	4	4	S.W.	b.	...	3

2 P.M.

Nairn	**29·96**	**57**	**55**	**W.N.W.**	**1**	—	—	**o.**	—	**2**
Valentia ..	**30·11**	**63**	**56**	**N.N.E.**	**3**	—	—	**c. b.**	—	**3**
Penzance ..	**30·04**	**60**	**53**	**N.**	**5**	—	—	**c.**	—	**4**
London	**29·87**	**63**	**55**	**N.**	**2**	—	—	**c.**	—	—
Rochefort ..	**29·96**	**65**	**60**	**N.W.**	**5**	—	—	**b.**	—	**3**

AUGUST 27, 1870.—8 A.M.

STATION.	Baro-meter.	Thermom.		Wind.		Extreme Wind.		Weather.	Rain-fall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Christiansund	?	53	48	E.S.E.	2	0	Z.	b.	—	2
Skudesnæs ..	29·74	50	48	N.N.W.	6	4	N.W.	b.	—	2
Oxo	29·71	53	50	N.N.W.	4	2	N.W.	b.	—	1
Helder	29·82	59	—	N.	4	—	—	—	—	2
Brussels ..	?	52	—	W.S.W.	3	—	—	b.	—	—
Paris	29·94	53	—	N.W.	3	—	—	b. c.	—	—
Cape Gris Nez	29·93	54	54	N.N.W.	4	7	N.N.W.	o.	0·04	3
Dover	29·92	58	56	N.N.W.	2	4	N.N.E.	b.	0·03	2
London	29·97	55	51	N.N.W.	2	4	N.	c. b.	...	—
Yarmouth ..	29·97	55	54	N.N.W.	3	4	N.N.W.	q. r. c.	0·27	3
Scarborough..	29·93	54	51	W.S.W.	1	6	N.	c. b.	0·05	2
Shields	?	59	55	N.N.W.	2	6	N.E.	b.	...	3
Leith	29·89	54	51	N.W.	2	2	N.W.	b. c.	...	—
Aberdeen ..	29·91	53	50	N.N.W.	2	1	N.N.W.	b. c.	0·01	1
Nairn	29·91	50	47	W.N.W.	1	2	W.N.W.	c.	0·03	1
Wick	29·91	56	53	N.	2	3	N.N.E.	c.	...	2
Thurso	29·92	51	49	Z.	0	4	N.N.E.	c.	0·03	0
Ardrossan ..	29·93	51	49	N.N.E.	2	3	N.N.W.	b.	...	1
Liverpool ..	29·94	57	53	N.	2	2	N.	c.	0·06	1
Holyhead ..	29·91	56	52	W.N.W.	1	5	W.	c.	...	—
Greencastle ..	29·90	55	53	S.W.	1	2	N.N.W.	c. o.	...	—
Valentia ..	30·00	61	58	W.S.W.	3	3	N.	b. r.	0·02	3
Crookhaven ..	?	62	58	W.N.W.	3	2	N.	b.	...	1
Roche's Point	29·98	65	61	S.W.	3	5	N.	c. o.	...	3
Pembroke ..	29·98	58	55	Z.	0	6	N.W.	c.	...	0

AUGUST 27, 1870.—8 A.M.—*continued.*

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Penzance ..	30·03	60	57	S.S.E.	1	5	N.	c.	...	1
Plymouth ..	30·02	56	53	W.	1	3	N.	c. f.	...	0
Portsmouth ..	29·97	55	52	N.	1	5	N.	c.	...	1
Brest	29·99?	54	52	N.W.	3	5	N.N.W.	o. b.	...	2
L'Orient ..	30·04	55	55	N.E.	3	5	N.E.	c.	...	2
Rochefort ..	30·02	57	55	N.E.	4	5	—	b.	...	3
Lyons	29·94	61	—	N.W.	3	—	—	c.	—	—
Biarritz	30·00	62	58	S.	3	5	N.	c.	...	5
Corunna ..	29·90	67	—	N.E.	3	—	—	b.	—	1

2 P.M.

Nairn	29·76?	61	52	W.N.W.	1	—	—	c. b.	—	1
Scarborough ..	29·89	59	54	E.	2	—	—	c.	—	2
Greencastle ..	29·82	53	52	S.S.E.	1	—	—	o. r.	—	—
Valentia ..	29·93	63	60	W.	5	—	—	r. o.	—	4
Penzance ..	30·01	66	59	W.	3	—	—	c.	—	2
London	29·94	66	54	W.	2	—	—	c.	—	—

AUGUST 28, 1870.—8 A.M.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Christiansund	?	53	49	S.S.E.	2	2	N.N.W.	b. c.	—	3
Skudesnæs ..	29·58	50	46	N.N.W.	4	4	N.W.	b.	—	2
Oxo	29·64	53	46	N.	4	—	—	—	—	—
Brussels ..	29·76	54	—	S.S.E.	3	—	—	o. r.	—	—
Paris	29·83	56	—	S.	2	—	—	o.	—	—
Cape Gris Nez	29·79	59	59	W.S.W.	9	4	W.	c. r.	0·08	6
Dover	29·54	59	59	W.	5	2	N.N.W.	b. r.	0·45	4
London	29·50	60	58	S.W.	5	7	S.S.W.	c. r. o.	0·59	—
Yarmouth ..	29·29	64	63	W.S.W.	4	4	S.S.E.	r.	0·67	4
Scarborough ..	29·24	57	56	N.E.	3	2	E.	c. r.	0·86	3
Shields	29·39	54	51	E.S.E.	5	6	S.E.	c. o.	0·69	4
Leith	29·49	55	52	E.	5	3	E.	b. r. o.	0·10	—
Aberdeen ..	29·61	55	51	N.E.	3	1	S.E.	c. p.	0·01	4
Nairn	29·62	53	49	E.N.E.	2	4	W.N.W.	c. o.	0·07	2
Wick	29·70	54	52	N.E.	3	3	N.N.E.	c.	...	2
Thurso	29·69	55	49	E.N.E.	3	2	E.N.E.	o. c.	...	2
Ardrossan ..	29·54	55	51	N.N.E.	3	2	S.E.	b. c.	0·50	2
Liverpool ..	29·34	60	58	W.N.W.	6	7	W.N.W.	r. o.	0·75	3
Holyhead ..	29·42	56	54	W.N.W.	6	5	S.S.W.	r. o.	0·80	—
Greencastle ..	29·63	56	53	N.	5	1	S.S.E.	r. o.	0·95	—
Valentia ..	29·64	57	54	N.N.W.	4	7	W.	r. c. p.	0·31	4
Crookhaven ..	—	64	61	W.N.W.	6	8	W.N.W.	o. b.	0·40	3

AUGUST 28, 1870.—8 A.M.—*continued.*

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Roche's Point	29·66	58	55	W.N.W.	6	6	W.N.W.	m. c.	0·04	4
Pembroke ..	29·54	61	59	W.N.W.	7	7	W.	o. c.	0·31	4
Penzance ..	29·74	63	62	W.	5	7	S.W.	c. r.	0·06	4
Plymouth ..	29·66	63	62	W.	3	5	W.	o. r.	0·05	2
Portsmouth ..	29·55	—	—	W.	6	6	W.S.W.	o. r.	0·28	5
Brest	28·80?	60	58	W.	4	4	N.N.W.	b. o.	...	3
L'Orient ..	29·93	60	58	W.	4	5	W.N.W.	c.	...	2
Rochefort ..	29·95	60	56	N.	3	5	N.W.	b. c.	...	3
Lyons	30·00	59	—	N.	3	—	—	c.	—	—
Biarritz.. ..	29·91	64	57	S.E.	4	5	N.	c. b.	—	3

AUGUST 29, 1870.—8 A.M.

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Christiansund	—	57	52	E.	4	0	Z.	b.	—	2
Skudesnæs ..	29·54	54	50	N.	4	4	N.	o. c.	—	2
Oxo	29·46	54	53	N.N.E.	6	4	N.N.E.	c. r.	—	3
Helder	29·28	56	—	N.N.W.	9	—	—	—	—	9
Dover	29·72	56	54	N.N.E.	3	6	W.	c. b.	0·11	2
London	29·80	55	50	N.N.W.	3	6	N.W.	p. c. b.	0·01	—
Yarmouth ..	29·64	56	53	N.W.	6	7	N.W.	q. r. c.	0·09	7
Scarborough..	29·74	52	50	N.	5	8	N.N.E.	r. c.	0·78	5
Shields	29·77	51	46	N.	4	6	N.N.E.	c. b.	0·55	6
Leith	29·80	54	48	N.W.	3	6	N.E.	o. b.	0·13	—
Aberdeen ..	29·79	51	48	N.N.W.	3	4	N.E.	o. c.	0·38	4
Nairn	29·83	51	48	N.W.	2	3	E.N.E.	o.	0·10	2
Wick	29·79	53	50	N.	3	—	—	c.	0·02	3
Thurso	29·78	52	48	N.N.E.	5	5	N.N.E.	c.	0·09	4
Holyhead ..	29·91	53	50	N.W.	4	6	N.W.	c.	—	—
Greencastle ..	29·97	54	51	N.	2	3	N.	c.	0·06	—
Valentia ..	30·04	56	52	N.E.	2	4	S.W.	p. b.	0·08	3
Crookhaven ..	—	55	51	N.E.	3	3	N.E.	c. q. b.	—	1
Roche's Point	29·98	53	50	N.	3	6	N.	c. q. b.	0·01	2
Pembroke ..	29·91	56	51	N.	4	6	W.N.W.	c.	—	1
Penzance ..	29·93	59	54	N.E.	4	6	N.W.	c. b.	0·05	4
Plymouth ..	29·91	57	54	N.	2	4	W.N.W.	c. m.	0·01	1
Portsmouth ..	29·82	55	52	N.	3	6	W.	c.	—	2
Brussels ..	29·57	56	—	W.S.W.	6	—	—	o.	—	—
Paris	29·79	56	—	W.N.W.	1	—	—	o.	—	—
Brest	29·88?	57	55	N.E.	3	4	W.	?	...	3
Rochefort ..	29·93	65	63	W.	5	5	N.E.	b. o.	...	3
Biarritz.. ..	29·99	65	63	S.	3	4	W.N.W.	b. f.	...	3
Corunna ..	29·97	69	—	N.W.	3	—	—	o.	—	2
Lyons	29·90	64	—	N.	3	—	—	b.	—	—
Toulon	29·91	63	53	S.W.	3	4	W.	b.	—	2

August 29, 1870.—2 p.m.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Nairn	29·88	54	50	N.W.	2	—	—	r. c.	—	2
Scarborough ..	29·83	56	51	N.	6	—	—	c.	—	5
Greencastle ..	30·01	56	53	N.N.W.	4	—	—	c.	—	—
Valentia ..	30·10	61	56	N.N.E.	3	—	—	c. b.	—	3
London	29·86	63	58	N.	3	—	—	b. c.	—	—

August 30, 1870.—8 a.m.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Christiansund	—	53	52	N.	2	4	N.N.E.	b. o.	—	2
Skudesnæs ..	29·69	53	50	N.W.	4	4	N.W.	c. b.	—	2
Oxo	29·63	54	51	N.N.W.	4	2	N.N.W.	b.	—	2
Helder	29·84	59	—	N.W.	7	—	—	—	—	5
Brussels ..	30·05	61	—	W.S.W.	3	—	—	b.	—	—
Paris	30·09	50	—	W.N.W.	1	—	—	b.	—	—
Cape Gris Nez	30·05	61	61	N.N.W.	4	7	N.W.	c. b.	...	3
Dover	30·07	55	53	N.	2	3	N.N.E.	b.	...	2
London	30·12	53	49	N.N.W.	2	4	N.	c. b.	...	—
Yarmouth ..	30·02	53	53	N.W.	4	6	N.W.	q. c.	0·08	4
Scarborough ..	30·09	54	51	N.	4	6	N.	c.	0·02	5
Shields	30·11	51	48	N.N.W.	3	4	N.N.W.	c. b.	0·03	4
Leith	30·12	50	46	N.W.	3	3	N.W.	b. c.	...	—
Aberdeen ..	30·10	53	49	N.N.W.	3	2	N.N.W.	c.	...	3
Nairn	30·14	55	52	N.E.	2	1	N.W.	b.	0·07	2
Wick	30·11	55	50	N.N.W.	3	3	N.N.W.	c.	0·06	3
Thurso	30·10	54	49	N.N.E.	4	5	N.N.E.	c. b.	0·02	4
Ardrossan ..	30·20	54	50	N.W.	2	4	N.N.W.	b.	...	1
Holyhead ..	30·21	55	53	N.N.W.	5	6	N.W.	c.	...	—
Greencastle ..	30·24	55	52	N.W.	2	4	N.N.W.	c.	...	—
Valentia ..	30·31?	53	50	N.	2	4	N.N.E.	t. b.	...	1
Crookhaven ..	30·27?	55	50	N.N.E.	3	4	N.N.E.	b.	...	0
Roche's Point	30·27	53	50	N.	3	4	N.	b.	...	1
Pembroke ..	30·22	55	51	N.	3	4	N.W.	c.	...	0
Penzance ..	30·24	56	54	Z.	0	5	N.E.	c. r.	...	1
Plymouth ..	30·21	56	53	N.N.E.	2	3	N.	c. f.	...	0
Portsmouth ..	30·13	54	54	N.	3	4	N.	c.	...	2
Brest	30·15?	55	53	N.N.E.	3	4	N.	b.	...	3
L'Orient ..	30·18	65	63	N.	5	4	N.W.	c. b.	...	1
Rochefort ..	30·10	55	53	E.	5	5	W.	o. b.	...	3
Lyons	30·04	63	—	N.	3	—	—	c.	—	—
Biarritz	30·02	64	62	S.E.	3	4	N.N.W.	f. o.	—	5
Corunna ..	30·02	67	—	N.E.	4	—	—	c.	—	2
Toulon	29·89	63	55	W.	1	3	W.	b. c.	...	2

AUGUST 30, 1870.—2 P.M.

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Scarborough..	30·20	57	52	N.	5	—	—	c.	—	5
Greencastle ..	30·30	58	52	N.	2	—	—	c.	—	—
Valentia ..	30·36	61	54	N.	2	—	—	b.	—	0
Penzance ..	30·30	60	53	N.E.	3	—	—	c.	—	2
London	30·19	63	54	N.N.W.	2	—	—	c.	—	—

CHAPTER VIII.

INSTANCES OF DEPRESSIONS IN A LATER STAGE.

We now proceed to describe the passage across Western Europe of one or two systems of retrograde circulation, which having originated at a considerable distance from our shores, traversed the latter in an advanced condition of development. The task of selection here becomes difficult simply from the abundance of materials, our variable climate having the merit of furnishing the observer with an endless multitude of examples of the transit of depressions, all of them approximating more or less closely to a single type, and exhibiting the operation of the same laws.

Instance I.

January 5–11, 1867.

Interesting charts of the progress of this depression are given in the Report to the Committee of the Meteorological Office, "On the Use of Isobaric Curves," &c., by Capt. H. Toynbee, F.R.A.S. We avail ourselves of the materials therein collected so far as these relate to the observations on board the ship 'Kiltearn,' which add a valuable item of information to the data which we possess for the investigation of this most instructive system.

Immediately previous to the approach of this disturb-

ance, no extensive systems of very high or very low pressure existed in Europe; barometric readings were generally somewhat uniform, and the currents feeble. These circumstances greatly facilitate the inquiry, for the course of the depression being comparatively free, and not signally interfered with by the complexity of the surrounding pressure conditions, the effects of the distribution of atmospheric temperatures and the influence of the law of precipitation are the more readily and distinctly traceable.

In the beginning of January temperatures were generally about the mean level for the season over the Mediterranean coasts, while in the extreme North of Europe an exceedingly intense frost prevailed. In the Central and N. Western districts the distribution of temperatures was slightly abnormal, the atmosphere over Germany, Holland, and France being rather warmer than that over the British Isles; these conditions resulting from an extensive baric depression which existed in France and Germany on the 1st and 2nd, the polar winds of which brought snow and frost to the British Isles, while the currents attracted from the Atlantic carried warmer temperatures to Continental Europe.

On the 4th of the month, atmospheric conditions were as follows :—Along the South coast of the Channel, and Eastwards as far as Denmark, thermometers ranged generally between 30° and 40°. South of this belt slight frost prevailed in Central France and in Germany; to the North the cold was intense in the inland localities of Great Britain, and at London at 8 A.M. the thermometer stood at 9°, being 30° lower than at Helder. The British Isles lay generally under a covering of deep snow. The temperature of the atmosphere upon the

Atlantic surface being generally on the increase, and its tension diminishing, a small area of direct circulation (centrifugal winds) existed in Great Britain, another in Ireland, a third over Central France, and a fourth, of somewhat higher pressure and greater intensity, in the Peninsula. These conditions, not uncommon in winter, are not necessarily indicative of approaching bad weather, and with the exception of the strong and increasing current from East at the entrance of the English Channel, and from South on the coast of Portugal, there were on this day but few symptoms of the coming disturbance noticeable on the European coasts. The 'Kiltearn,' however, at 45° 40′ N., 16° 5′ W., experienced a S.S.W. gale, with a barometer at 29·30.

On the morning of the 5th these conditions had undergone very considerable change. The little node of direct currents which on the previous day had existed in Great Britain had passed to the N.E., and its pressures had risen to 30·20. The great depression was advancing towards the entrance of the Channel, where a S.E. storm was blowing. At Lisbon there raged a gale from S., barometer 29·83; while on board the 'Kiltearn,' 45° 5′ N., 16° 3′ W., pressure was 28·90 with a W.S.W. hurricane. Temperatures were below zero at some localities in Aberdeenshire; at Nairn, thermometers at 9 A.M. stood at 11°; in London, 19°; while at Penzance they had risen to 45°; and on the North coast of Spain to 57°. Thermal conditions were thus most favourable to excessive precipitation in the N. Eastern arc of the circulation. The sky was overcast throughout France and Spain, rain was falling on the Western coasts of France and in Portugal; the edge of the enormous bank of Cirrus and composite cloud travelling with a Westerly upper-current gale, extended from N.W. to

S.E. across England, while in Scotland the sky was clear.

During the latter part of this day exceedingly heavy precipitation occurred on the Western shores of the British Isles and of France. In parts of the South coast of Cornwall the fall was upwards of 2 inches, while upon the Devon and Dorset coast it exceeded 1 inch, as also on French N. Western stations, and on the South coast of Ireland. Pressures diminished rapidly over this district, while in the extreme S.W. and S.E., on board the 'Kiltearn,' in Portugal, Spain, and on the Mediterranean coasts a brisk increase of pressure was observed. A S.E. gale of extraordinary violence raged during the afternoon in the Channel, extending at night to the North Sea.

The greatest precipitation followed by the region of lowest pressure now took a Northward direction. On the 6th, rainfalls of between ½ and 1½ inch occurred in the West of Ireland, while in the East it was equally heavy. Upwards of 1½ fell at Dublin and in Western Wales, and at some points, both in Wales and Monmouthshire, more than 2 inches fell on this day, the precipitation occurring as snow, changing to rain, and accompanied in many localities by thunder and lightning. In the extreme North and East of Great Britain only a few snow-showers fell. At 8 A.M. of the 6th pressures below 28·80 existed on the West coast of Ireland. From Valentia to Skudesnæs the gradient was ·091 per 50 geographical miles, to Oporto ·090. In lat. 44° 59′ N., long. 15° 13′ W., a W.S.W. gale was blowing, sweeping Northwards in France, to a S. gale at Yarmouth, and a S.E. at Shields and Aberdeen. Across Central Europe, from the Baltic to the Adriatic, an extensive area of pressures above 30·25

existed, with hard frost; while to the Eastward again of this region lay another system of depression with strong gales, which having traversed the Black Sea on the previous day, was now progressing across Russia to the N.E. In the extreme North of Europe the most intense frost was experienced, while in the S.W. the atmosphere was extraordinarily warm; thermometer returns ranging from -31° in the Gulf of Bothnia to 65° on the North coast of Spain, a difference of 96° Fahrenheit!

On the evening of the 6th the centre of depression had advanced to the North of Ireland, and here its progress was temporarily checked; for though temperature at the coast stations continued lower in the North and N. West than elsewhere, precipitation was arrested in the Northern section of the area, the water-vapour being abundantly deposited on the high lands of Wales and the North of England. The following day, the 7th, was the wettest of the series in the English Midland and Northern counties, throughout which upwards of $\frac{1}{2}$ inch of rain fell in nearly every locality, while at the more elevated stations the fall was upwards of an inch, and considerably so at the rainiest, *e.g.* 2·07 inches at Llanberis and 3·28 at Borrowdale. There occurred on this day one of those great atmospheric oscillations which characterize almost every extensive system of depression, imparting to the gales which accompany it their spasmodic and intermittent nature. During these pressure often suddenly gives way and then recovers again on one side or other of the baric minimum, sometimes without any alteration in the geographical position of the latter; the alternate divergence and convergence of the isobarics exhibit in these cases the conflict of the

elemental forces; the efforts of the atmosphere to regain the equilibrium and the disturbing influences of the changes of tension gaining the ascendancy in turns. In the present instance pressures continued to decrease to the N. Eastward of the minimum, without any advance of the latter, and the force of the S.E. current in the North Sea consequently diminished; but in the S. West, at the entrance of the Channel, a rapid decrease also occurred, while in the South of France and in the Peninsula there was a tendency to an increase; consequently there was a further augmentation in the violence of the S. Westerly currents. On board the 'Kiltearn,' now in lat. 45° 35′ N., long. 15° 30′ W., pressure had again fallen below 29 inches at 4 A.M., the wind had backed to S.W., and blew with a force of 12, the gradient to Lisbon being ·113 per 50 geographical miles. In the evening this increase of intensity reached our Channel shores, along which the S.W. storm blew with an estimated force of 10 and upwards at every station.

Plate XXII. exhibits the system in N. Western Europe at 8 A.M. of the 8th, when the centre of depression still hung over the Irish Sea, with pressures below 28·50 in. The currents drawn into the helix were now of great extent, the belt of Westerly winds extending from this point to Gibraltar, and that of Southerly winds to St. Petersburg. A N. W. gale, force 9, was blowing at Valentia, and with force 10, in lat. 45° 17′ N., long. 14° 21′ W., the gradient for this current being ·089. The weather continued hitherto persistently dry on the Mediterranean coasts. The area of high pressures which had previously existed in Central Europe was slowly migrating Eastward, and at Moscow the barometer had now risen to 30·42, while in

the Black Sea pressures continued to rise, with N. and N.W. gales.

During this day heavy precipitation again occurred, both in the South and West of Ireland and in the North and West of Scotland, as also in Western and Central France. The oscillations of pressure were considerable, but the general tendency was to an increase in N. Western Europe. The position of the depression centre continued nearly unaltered, and on the morning of the 9th the minimum still hung over the Irish Sea, a little to the South of the situation occupied on the two preceding mornings. On our East coast, in Holland, Northern Germany, and Denmark, but little rain fell, and the sky at many stations in this direction continued clear; for, the frost still continuing in Central Europe, the Southerly winds on the North Sea coasts were not of the precipitating type.

Meanwhile several supplementary disturbances began to develop themselves on the exterior of the great system. The atmosphere slowly set in motion Eastwards in the Mediterranean began to part with its vapour in heavy rain in Italy, and the reports for 8 A.M. of the 9th show the existence of an incipient helix of considerable intensity over this region, a S.E. gale with heavy rain and a high sea prevailing in the Adriatic, an Easterly current with rapidly rising temperature in Austria, and a brisk sirocco in Southern Italy and Sicily. The centre of this depression passed rapidly to E.N.E., the winds changing to N. in the Adriatic on the evening of the 9th.

Heavy and continuous snow is reported on this day from Sweden and the Baltic coasts, and here another system of circulation became rapidly developed, the winds in Norway and over the North Sea changing to

N. with a rapid barometric fall, while in Denmark and Northern Germany they veered towards W. This depression also swept rapidly to the Eastward, without interfering with the persistent circulation over the British Isles, the English weather reports, except those from the East coast, scarcely giving indications of its existence.

On the evening of the 9th a great change suddenly began to take place in the British depression, heralded by a sudden cessation of precipitation in the North and West of Ireland and Scotland, and the occurrence of very heavy rain upon the English East coast, in Holland, Belgium, and Southern Norway. The baric minimum now passed to the Eastward, pressure recovering six-tenths in Ireland with a N. gale in the Irish Sea, and a very violent W. gale on the Northern coast of France. Plate XXIII. exhibits the system, at 8 A.M. of the 10th, when the lowest reported pressure, 28·78, was at Dunkirk. To the North of this point the gradients for Easterly winds were low, pressure in Norway recovering but slowly from the effects of the Baltic depression, and the barometer at Christiansund standing at 29·32, while to the South the gradients from Westerly winds were very high, that from Dunkirk to Paris being ·192 per 50 geographical miles.

The Baltic depression had passed into Finland, with central pressures below 29 inches, the wind being strong from N. in the Gulf of Bothnia, and from S.W. in the Gulf of Finland.

In the Adriatic another small depression existed.

The progression of our great depression now became extremely rapid to E. and subsequently to N.E. On the morning of the 11th the centre of the system existed a little to the North of the Gulf of Finland, its

translation having been at the rate of about 38 geographical miles per hour, with a great diminution of intensity. Southerly and S. Westerly winds were now experienced in the Black Sea and throughout Russia, the thaw extending to Moscow and Petersburg; while severe frost again set in on the Western shores of Europe, where the polar current which the great depression had established began to veer to N.E., being liberated from its Eastward attraction. The subsequent weather was characterized by Mediterranean depressions and by severe frost and snowstorms in the N. West of Europe.

Plate XXIV. represents the track of the great depression, and those of the supplementary systems, across Europe, so far as it has been found possible to determine them, and the position (approximately correct) of the mean isothermals on the days immediately preceding the disturbance.

METEOROLOGICAL REPORTS.

JANUARY 5, 1867.—8 A.M.

Station.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Haparanda ..	29·61	−13	—	S.E.	1	—	—	o.	—	—
Riga	29·82	33	—	W.	1	—	—	—	—	—
Hernosand ..	29·76	−6	—	W.	3	—	—	b.	—	—
Stockholm ..	29·86	3	—	W.S.W.	3	—	—	b.	—	—
Christiansund	29·96	27	—	W.	6	—	—	o. s.	—	6
Skudesnæs ..	30·18	21	—	S.W.	3	—	—	b.	—	2
Groningen ..	30·19	32	—	N.	3	—	—	b.	—	—
Helder	30·17	33	—	E.N.E.	4	—	—	b.	—	3
Brussels ..	30·19	24	—	S.S.W.	4	—	—	o.	—	—
Strasburg ..	29·84?	25	—	N.	3	3	N.E.	o.	—	—
Paris	30·12	28	—	E.S.E.	3	4	E.	o.	...	—
London	30·09	19	—	S.E.	1	3	W.	f. m.	...	—
Yarmouth ..	30·12	34	—	S.E.	7	8	N.W.	o.	...	5
Scarborough ..	30·12	32	—	S.	1	2	N.N.W.	s. c.	0·11	2

January 5, 1867.—8 a.m.—*continued.*

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Shields	30·13	21	—	S.W.	2	3	N.W.	o.	...	—
Aberdeen ..	30·14	14	—	W.	1	2	N.W.	b. m.	...	1
Nairn	30·14	11	—	S.W.	1	1	S.W.	b.	...	2
Ardrossan ..	30·04	26	—	E.N.E.	3	3	E.	f.	...	2
Holyhead ..	29·92	31	—	E.S.E.	2	1	E.S.E.	c. b.	...	2
Greencastle ..	29·95	35	—	S.E.	4	5	W.	s. c.	0·01	3
Valentia ..	29·29	41	—	S.E.	8	5	E.	b. o.	...	4
Roche's Point	29·54	41	—	S.E.	8	8	E.	o.	...	6
Penzance ..	29·69	45	—	S.E.	10	9	E.S.E.	c. r.	...	8
Plymouth ..	29·82	37	—	E.	8	2	E.N.E.	c. o.	...	5
Portsmouth ..	30·00	30	—	E.S.E.	3	2	E.N.E.	c. m.	...	2
Havre	29·99	33	—	E.	8	5	E.N.E.	f.	—	4
Cherbourg ..	29·96	30	—	S.E.	5	5	S.E.	o.	—	3
Brest	29·55	36	—	S.E.	7	6	E.S.E.	r. s.	0·12	5
L'Orient ..	29·76	36	—	E.S.E.	6	7	E.N.E.	c. h.	0·47	5
Rochefort ..	29·81	39	—	E.S.E.	4	4	E.	r.	0·47	2
Limoges ..	29·83	33	—	N.E.	3	3	E.	o.	—	—
Montauban ..	29·98	39	—	S.E.	3	2	W.	r.	—	—
Bayonne ..	29·72	48	—	S.	2	—	—	o.	—	6
Bilbao	29·68	57	—	S.W.	6	—	—	o.	—	3
Corunna ..	29·52	52	—	S.W.	9	—	—	r.	—	5
Lisbon	29·83	55	—	S.	9	—	—	o. r.	—	—
Cadiz	30·12	47	—	E.	5	—	—	o.	—	1
Madrid	30·16	33	—	S.	2	—	—	o.	—	—
Barcelona ..	29·98	49	—	W.	3	—	—	b.	—	2
Cette	29·84	41	—	N.E.	2	—	—	c.	—	0
Lyons	30·18	30	—	N.E.	3	—	—	o.	—	—
Marseilles ..	29·98	36	—	N.N.E.	3	2	N.N.W.	c.	—	0
Toulon	29·92	36	—	E.N.E.	3	3	W.N.W.	c.	—	6
Leghorn ..	30·03?	36	—	N.E.	1	4	N.E.	b.	—	3
Naples	29·80	50	—	N.	3	3	N.E.	b.	—	3
Ancona	29·90	42	—	N.	7	6	N.N.W.	c. o.	—	6
Lesina	29·76	—	—	N.	5	—	—	b.	—	5
Trieste	29·98	35	—	E.	6	—	—	b.	—	1
Vienna	30·04	22	—	W.	5	0	Z.	b. c.	—	—
Odessa	29·51	42	—	S.E.	4	—	—	c.	—	5

January 6, 1867.—8 a.m.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Haparanda ..	30·01	−31	—	Z.	0	—	—	b.	—	—
Petersburg ..	30·03	−6	—	N.W.	2	—	—	b.	—	—
Riga	30·25	21	—	N.	3	—	—	o.	—	—
Helsingfors ..	30·24	5	—	Z.	0	—	—	b.	—	—
Stockholm ..	30·23	3	—	S.S.W.	2	3	W.S.W.	b.	—	—

JANUARY 6, 1867.—8 A.M.—*continued.*

STATION.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Christiansund	30·00	27	—	W.S.W.	6	—	—	s.	—	—
Skudesnæs ..	30·05	30	—	S.E.	6	—	—	c.	—	4
Groningen ..	29·86	21	—	E.	5	—	—	o.	—	—
Helder	29·55	41	—	S.E.	5	—	—	o.	—	5
Brussels ..	29·72	35	—	E.S.E.	7	—	—	o.	—	—
Strasburg ..	30·01	39	—	S.W.	1	2	N.	o.	—	—
Paris	29·69	33	—	S.E.	2	8	E.S.E.	o.	—	—
London	29·42	46	—	S.	2	8	S.S.E.	h. f. o.	—	—
Yarmouth ..	29·45	36	—	S.	10	11	S.E.	o. r.	—	—
Scarborough ..	29·40	34	—	S.	5	7	S.S.E.	r.	—	4
Shields	29·37	40	—	S.S.E.	8	7	S.E.	o.	—	6
Aberdeen ..	29·40	35	—	S.E.	8	4	S.E.	o.	—	7
Ardrossan ..	29·23	36	—	—	—	7	E.	—	—	—
Holyhead ..	29·14	46	—	S.S.W.	5	8	E.S.E.	s.	—	—
Greencastle ..	29·09	40	—	W.	1	—	—	r. o.	—	—
Valentia ..	28·77	40	—	S.	7	8	S.E.	r.	—	5
Roche's Point	28·94	45	—	S.	6	9	S.E.	—	—	—
Penzance ..	29·28	49	—	S.W.	2	11	S.E.	r. f.	—	6
Plymouth ..	29·32	46	—	S.S.W.	2	10	E.S.E.	r.	—	7
Portsmouth ..	29·38	46	—	S.S.W.	5	10	S.	r.	—	6
Havre	29·33	41	—	S.E.	5	9	S.	c.	—	6
Cherbourg ..	29·52	45	—	S.S.W.	1	—	—	r.	—	5
Brest	29·40	46	—	S.W.	1	8	S.E.	o.	—	6
L'Orient ..	29·41	53	—	—	—	7	E.S.E.	—	—	—
Rochefort ..	29·61	46	—	S.S.W.	6	7	E.	o.	—	6
Limoges ..	29·78	46	—	S.W.	2	3	N.W.	r. o.	—	—
Montauban ..	29·86	42	—	S.	3	3	S.E.	o.	—	—
Bayonne ..	29·68	54	—	S.	5	4	S.	o.	—	5
Bilbao	29·73	65	—	S.W.	6	—	—	o. r.	—	2
Corunna ..	29·76	53	—	S.W.	6	8	S.W.	r.	—	—
Oporto	29·94	59	—	S.W.	7	—	—	o. r.	—	—
Lisbon	30·04	60	—	S.W.	8	10	S.S.W.	r. o.	—	—
Alicante ..	30·12	50	—	W.	6	—	—	o. r.	—	2
Madrid	30·06	44	—	E.	1	—	—	f. r.	—	—
Barcelona ..	29·92	54	—	W.	1	—	—	o.	—	1
Cette	30·04	46	—	E.	5	—	—	r.	—	5
Lyons	30·00	41	—	S.	2	3	N.	r.	—	—
Marseilles ..	30·03	46	—	E.	7	1	W.	o.	—	6
Toulon	30·00	45	—	N.E.	6	—	—	r.	—	5
Berne	30·06	14	—	S.E.	1	3	N.W.	s.	—	—
Leghorn ..	30·27	36	—	E.N.E.	5	—	—	m.	—	1
Rome	30·22	31	—	N.W.	—	—	—	b. c.	—	—
Naples	30·16	37	—	S.W.	3	—	—	c.	—	2
Palermo ..	30·08	52	—	W.S.W.	1	—	—	r.	—	2
Lesina	30·18	32	—	E.	5	—	—	b.	—	4
Trieste	30·24	31	—	E.	6	—	—	b.	—	—
Vienna	30·32	19	—	W.N.W.	1	6	W.N.W.	b.	—	—
Odessa	29·33	37	—	W.	8	—	—	r.	—	7

JANUARY 7, 1867.—8 A.M.

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Haparanda	30·04	28	—	S.E.	4	—	—	o.	—	—
Petersburg	30·22	15	—	Z.	0	—	—	o.	—	—
Riga	30·35	−3	—	N.	2	—	—	b.	—	—
Hernosand	29·97	8	—	Z.	0	—	—	o.	—	—
Stockholm	30·06	24	—	E.S.E.	1	3	W.S.W.	o.	—	—
Christiansund	29·56	27	—	S.E.	2	—	—	o.	—	—
Skudesnæs	29·40	33	—	S.E.	6	—	—	o.	—	—
Groningen	29·50	32	—	S.	4	—	—	o.	—	—
Helder	29·44	41	—	S.S.W.	5	—	—	s. o.	—	6
Dunkirk	29·50	41	—	S.	2	6	S.S.E.	s. o. r.	—	1
Strasburg	29·92	37	—	S.	4	1	S.W.	r. o.	—	—
Paris	29·65	46	—	S.S.W.	6	7	S.S.E.	o. r.	0·44	—
London	29·34	48	—	S.S.W.	6	3	S.S.W.	r.	0·42	—
Yarmouth	29·33	45	—	S.S.W.	8	9	S.	r.	0·31	6
Scarborough	29·08	44	—	S.	4	4	S.	o.	0·20	4
Shields	28·96	40	—	S.E.	3	5	S.W.	o.	—	4
Leith	28·89	40	—	E.	1	5	S.E.	c.	0·18	1
Aberdeen	28·91	41	—	S.S.E.	1	8	S.S.E.	r. m.	0·43	1
Nairn	28·94	36	—	S.S.W.	1	2	S.W.	m.	0·35	3
Ardrossan	28·84	37	—	E.	3	7	E.	r. o.	0·50	2
Holyhead	28·94	50	—	S.S.W.	6	5	S.S.W.	o.	0·15	5
Valentia	28·83	50	—	W.S.W.	4	8	S.W.	r.	0·58	5
Penzance	29·15	52	—	W.S.W.	7	3	S.W.	o.	2·07	6
Plymouth	29·20	53	—	S.W.	8	8	S.S.W.	r.	2·07	6
Weymouth	29·25	52	—	S.S.W.	8	7	S.	r.	1·31	6
Portsmouth	29·28	50	—	S.S.W.	8	10	S.W.	r.	0·61	7
Havre	29·45	45	—	S.W.	6	6	S.S.W.	o. r.	—	6
Cherbourg	29·40	52	—	S.S.W.	7	7	S.W.	r.	—	7
Brest	29·36	57	—	S.S.W.	6	3	S.W.	o.	1·11	7
L'Orient	29·40	55	—	S.	7	8	S.W.	r.	1·49	7
Bayonne	29·72	57	—	S.W.	6	—	—	b. c.	—	7
Bilbao	29·72	68	—	S.W.	7	—	—	o.	—	2
Corunna	29·63	56	—	S.W.	8	—	—	b. c. r.	—	3
Lisbon	30·03	61	—	S.S.W.	9	9	S.S.W.	p. r.	—	7
Cadiz	30·18	62	—	S.E.	7	—	—	o. r.	—	—
Alicante	30·18	59	—	S.	2	—	—	o.	—	1
Madrid	30·12	51	—	S.W.	4	—	—	r.	—	—
Barcelona	30·05	55	—	—	—	—	—	—	—	—
Lyons	30·04	41	—	S.E.	3	3	S.	r. o.	—	—
Toulon	30·04	41	—	N.E.	2	7	E.	r.	—	7
Antibes	—	—	—	N.	3	8	E.	r. c.	—	6
Berne	29·91	28	—	S.E.	1	—	—	f.	—	—
Lesina	30·09	36	—	E.	2	—	—	s. o.	—	1
Trieste	30·14	37	—	E.	2	—	—	b.	—	0
Vienna	30·06	19	—	S.S.E.	5	7	E.S.E.	s.	—	—
Odessa	29·68	16	—	N.	8	8	N.W.	o.	—	6

JANUARY 8, 1867.—8 A.M.

STATION.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Haparanda ..	29·91	−7	—	N.E.	3	—	—	b.	—	—
Petersburg ..	30·21	12	—	S.	—	—	—	o.	—	—
Riga	29·95	15	—	S.E.	7	—	—	o.	—	—
Hernosand ..	29·44	28	—	S.E.	5	—	—	s.	—	—
Stockholm ..	29·41	30	—	S.	6	6	S.	s.	—	—
Skudesnæs ..	29·12	26	—	E.	—	—	—	—	—	—
Groningen ..	29·14	44	—	S.	3	—	—	o.	—	—
Helder	29·00	46	—	S.	6	—	—	b. o.	—	6
Dunkirk ..	28·98	50	—	S.S.W.	8	—	—	r.	—	7
Brussels ..	29·15	53	—	S.S.E.	7	—	—	o.	—	—
Strasburg ..	29·60	43	—	S.W.	1	5	S.W.	r.	—	—
Paris	29·25	52	—	S.W.	7	8	S.	o.	0·07	—
London	28·71	52	—	W.S.W.	8	11	S.W.	c. o. r.	0·18	—
Yarmouth ..	28·77	49	—	S.W.	9	10	S.S.W.	r.	0·23	6
Scarborough ..	28·61	47	—	S.S.E.	2	8	S.	r. o.	0·14	3
Shields	28·59	45	—	S.E.	2	3	S.W.	o.	—	3
Leith	28·61	43	—	N.E.	1	1	N.	f.	0·15	1
Aberdeen ..	28·64	40	—	N.	1	1	S.S.E.	r. f.	0·10	1
Nairn	28·67	34	—	S.E.	1	1	S.E.	f. r. c.	0·06	3
Ardrossan ..	28·51	40	—	E.	3	3	S.E.	o.	0·25	2
Holyhead ..	28·51	49	—	S.W.	5	5	S.S.W.	r.	0·51	5
Greencastle ..	28·54	43	—	W.	1	—	—	—	—	—
Valentia ..	28·78	46	—	N.W.	9	7	W.	r. c.	0·42	6
Penzance ..	28·87	50	—	W.	6	11	S.W.	r. c.	—	8
Plymouth ..	28·83	50	—	W.	9	11	S.S.W.	r.	—	8
Portsmouth ..	28·82	51	—	W.S.W.	10	10	S.S.W.	r.	0·24	9
Havre	29·05	50	—	S.W.	10	5	S.W.	r. o.	—	9
Cherbourg ..	29·00	52	—	S.W.	8	—	—	r.	—	7
Brest	29·13	49	—	S.	7	10	S.W.	r. o.	0·08	6
L'Orient ..	29·19	52	—	S.W.	9	9	S.S.W.	o. r.	0·20	8
Rochefort ..	29·45	54	—	S.W.	9	4	S.W.	o.	0·12	6
Limoges ..	29·62	50	—	S.	4	7	W.	o.	—	—
Montauban ..	29·73	46	—	S.W.	3	3	S.	c.	—	—
Bayonne ..	29·57	57	—	S.	4	—	—	r.	—	6
Bilbao	29·63	59	—	W.	7	—	—	o.	—	2
Oporto	29·80	54	—	S.W.	6	—	—	o.	—	6
Lisbon	29·95	58	—	W.S.W.	9	10	S.W.	p. r.	—	7
Cadiz	30·07	59	—	S.	3	—	—	o.	—	5
Alicante ..	29·97	55	—	S.W.	1	—	—	c.	—	0
Madrid	29·89	47	—	S.W.	7	—	—	o.	—	—
Barcelona ..	29·80	56	—	N.W.	1	—	—	o.	—	—
Cette	30·08?	48	—	S.W.	6	5	N.E.	r.	—	6
Lyons	29·74	52	—	S.	6	—	—	b.	—	—
Marseilles ..	29·79	50	—	S.S.E.	7	2	N.E.	b. c.	—	7
Antibes ..	—	—	—	N.E.	7	—	—	o. r.	—	6
Berne	29·75	35	—	S.E.	2	1	S.E.	f.	—	—
Leghorn ..	30·04	37	—	E.N.E.	5	—	—	o.	—	1
Rome	30·12	36	—	N.W.	—	—	—	o.	—	2
Naples	30·19	41	—	W.	2	3	N.E.	c.	—	4
Palermo ..	30·08	48	—	W.S.W.	2	—	—	c.	—	0
Ancona	30·00	38	—	W.N.W.	1	—	—	o.	—	5
Lesina	30·08	40	—	E.	2	—	—	c.	—	4
Trieste	30·08	43	—	E.	1	—	—	c.	—	0
Vienna	29·91	21	—	S.E.	3	2	S.E.	c.	—	—
Moscow ..	30·42	28	—	W.	2	—	—	c.	—	—

JANUARY 9, 1867.—8 A.M.

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Skudesnæs ..	28·86	37	—	N.	2	2	E.	c.	—	1
Groningen ..	29·23	40	—	S.S.W.	1	—	—	b. c.	—	—
Helder	29·17	42	—	S.W.	6	—	—	b. m.	—	6
Dunkirk ..	29·24	41	—	S.W.	6	—	—	c.	—	2
Brussels ..	29·30	45	—	S.	3	—	—	f.	—	—
Strasburg ..	29·64	45	—	S.W.	3	6	S.W.	r.	—	—
Paris	29·38	43	—	S.W.	4	8	S.W.	c.	0·15	—
Boulogne ..	29·29	46	—	S.W.	9	—	—	r. o.	—	7
London	29·11	44	—	S.S.W.	5	8	W.S.W.	r. b. c.	0·01	—
Yarmouth ..	29·11	41	—	S.S.W.	4	10	W.N.W.	o. b.	...	3
Scarborough..	28·98	38	—	S.S.W.	2	3	W.	c. b.	...	2
Shields	28·94	40	—	S.W.	2	2	N.W.	f.	0·10	2
Leith	28·96	39	—	N.N.E.	1	1	N.E.	m. o.	0·18	1
Aberdeen ..	28·99	38	—	N.E.	4	8	N.	r.	0·46	3
Nairn	29·05	39	—	E.N.E.	4	7	E.	l. r.	1·03	5
Ardrossan ..	28·87	39	—	E.	3	2	S.	o. c.	0·17	2
Holyhead ..	28·60	45	—	S.E.	5	8	W.S.W.	c. r.	0·25	5
Greencastle ..	28·88	42	—	E.N.E.	4	—	—	—	—	—
Valentia ..	28·86	47	—	N.W.	3	11	W.	r. c.	0·53	5
Roche's Point	28·70	42	—	N.W.	8	10	W.S.W.	—	—	—
Penzance ..	29·07	48	—	W.	9	10	W.S.W.	o. r.	0·11	8
Plymouth ..	28·99	48	—	W.	10	8	S.S.W.	c. h. o.	0·23	8
Portsmouth ..	29·10	45	—	S.S.W.	6	10	W.S.W.	c. r.	0·10	5
Havre	29·27	46	—	S.W.	6	8	S.W.	o.	—	6
Cherbourg ..	29·25	45	—	S.S.W.	6	7	W.S.W.	r.	—	7
Brest	29·30	45	—	W.	9	7	W.S.W.	r. o.	0·16	8
L'Orient ..	29·35	49	—	W.S.W.	7	7	W.S.W.	c.	0·24	7
Rochefort ..	29·53	48	—	W.	5	7	S.W.	r. o.	0·08	7
Limoges ..	29·60	43	—	W.	3	4	S.W.	c.	—	—
Montauban ..	29·75	45	—	S.E.	3	4	S.W.	c.	—	—
Bayonne ..	29·61	54	—	S.W.	4	2	S.W.	r.	—	7
Bilbao	29·65	60	—	—	—	—	—	o.	—	4
Corunna ..	29·64	55	—	S.W.	6	4	S.W.	r.	—	4
Lisbon	30·08	53	—	S.W.	6	—	—	r.	—	5
Alicante ..	30·09	55	—	N.W.	5	—	—	c.	—	2
Madrid	30·04	46	—	S.W.	6	—	—	o.	—	—
Cette	29·88	48	—	N.W.	3	5	S.S.E.	b.	—	2
Lyons	29·68	46	—	S.E.	2	3	S.	o.	—	—
Marseilles ..	29·76	48	—	W.N.W.	5	5	S.E.	c.	—	4
Toulon	29·65	48	—	W.N.W.	5	7	E.N.E.	b. c.	—	6
Leghorn ..	29·67	55	—	W.S.W.	5	—	—	r.	—	—
Rome	29·73	55	—	S.S.W.	6	—	—	r.	—	—
Ancona	29·57	48	—	S.E.	3	2	S.E.	r.	—	4
Lesina	29·85	50	—	E.S.E.	9	—	—	r.	—	7
Trieste	29·73	41	—	S.E.	7	—	—	r.	—	4
Vienna	29·71	41	—	E.N.E.	5	5	E.S.E.	o.	—	—

JANUARY 10, 1867.—8 A.M.

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Haparanda ..	28·97	6	—	N.E.	7	—	—	s.	—	—
Petersburg ..	29·36	31	—	S.W.	4	—	—	o.	—	—
Helsingfors ..	29·19	44	—	W.S.W.	7	—	—	s. o.	—	—
Hernosand ..	29·19	-3	—	N.	2	—	—	s. c. b.	—	—
Stockholm ..	29·52	20	—	E.N.E.	3	3	S.	r. s.	—	—
Christiansund	29·32	25	—	E.	4	—	—	o.	—	4
Skudesnæs ..	29·11	34	—	E.	2	2	N.	r.	—	1
Groningen ..	28·99	39	—	S.	2	—	—	o. r.	—	—
Helder	28·91	41	—	S.	6	—	—	o. r.	—	5
Brussels ..	29·13	47	—	S.S.W.	7	—	—	o.	—	—
Strasburg ..	29·76?	46	—	S.	1	3	W.	r.	—	—
Paris	29·28	45	—	S.W.	4	7	S.W.	r.	0·09	—
Boulogne ..	28·98	45	—	W.	10	9	W.S.W.	r.	—	8
London	29·07	40	—	N.N.W.	4	9	S.S.W.	r. c.	0·35	—
Yarmouth ..	28·88	43	—	N.W.	4	10	S.S.W.	r. o.	0·31	5
Scarborough ..	29·03	40	—	N.	8	10	N.	r. o.	0·51	6
Shields	29·15	40	—	N.E.	8	8	N.E.	r. o.	0·65	8
Aberdeen ..	29·26	35	—	N.	3	2	N.	s. h.	0·29	5
Nairn	29·33	36	—	E.N.E.	3	7	E.N.E.	h. o.	0·12	5
Ardrossan ..	29·35	37	—	N.	3	7	E.	o. c.	0·02	2
Holyhead ..	29·23	41	—	N.N.W.	8	4	E.S.E.	r. o.	0·16	7
Greencastle ..	29·42	40	—	N.E.	4	—	—	—	—	—
Valentia ..	29·46	40	—	N.E.	1	5	N.W.	r. b.	0·21	2
Roche's Point	29·39	39	—	N.N.E.	6	—	—	—	—	—
Penzance ..	29·34	43	—	N.N.W.	4	9	W.N.W.	o.	0·16	5
Plymouth ..	29·29	43	—	W.N.W.	5	10	W.	c. o.	0·15	4
Portsmouth ..	29·15	45	—	N.N.W.	3	10	S.W.	r. o.	0·16	3
Havre	29·19	48	—	W.S.W.	9	8	S.W.	o.	—	8
Cherbourg ..	29·27	46	—	S.W.	7	8	S.S.W.	o.	—	7
Brest	29·33	45	—	N.W.	5	7	W.S.W.	h. c.	0·24	5
L'Orient ..	29·33	48	—	W.	4	6	W.S.W.	c. r.	0·28	7
Rochefort ..	29·53	50	—	W.	7	5	S.W.	r. o.	0·59	8
Limoges ..	29·55	50	—	S.	4	6	S.W.	o.	—	—
Montauban ..	29·66	41	—	S.	3	3	S.	o.	—	—
Bayonne ..	29·61	52	—	S.W.	2	5	W.	r.	—	9
Bilbao	29·67	54	—	W.	7	—	—	o.	—	4
Barcelona ..	29·74	59	—	N.	7	—	—	o.	—	2
Cette	29·68	50	—	S.	2	2	S.W.	b. c.	—	5
Lyons	29·59	52	—	S.	4	3	S.W.	c.	—	—
Marseilles ..	29·68	50	—	E.	2	2	W.	c.	—	6
Toulon	29·61	45	—	Z.	0	3	S.S.W.	b. c.	—	6
Leghorn ..	29·76	53	—	S.	3	6	S.W.	c.	—	1
Rome	29·85	54	—	W.	3	—	—	o.	—	6
Naples	29·90	55	—	W.S.W.	6	—	—	c.	—	6
Palermo ..	29·97	57	—	Z.	0	7	S.	c. o.	—	1
Lesina	29·80	54	—	S.E.	6	4	N.	o.	1·22	5
Trieste	29·73	47	—	S.E.	3	4	N.	c.	0·92	1
Vienna	29·51	32	—	S.S.E.	3	0	Z.	f.	—	—

JANUARY 11, 1867.—8 A.M.

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rainfall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Haparanda ..	29·25	—	—	—	—	—	—	—	—	—
Petersburg ..	29·14	34	—	S.S.W.	8	—	—	o.	—	—
Helsingfors ..	29·08	24	—	W.S.W.	3	—	—	o.	—	—
Riga	29·13	35	—	S.W.	3	—	—	o.	—	—
Hernosand ..	29·25	—	—	W.	—	—	—	b.	—	—
Stockholm ..	29·27	16	—	N.	3	3	N.	o.	—	—
Christiansund	29·35	25	—	N.	6	—	—	s.	—	5
Skudesnæs ..	29·31	27	—	N.	5	2	N.E.	s.	—	3
Groningen ..	29·22	38	—	S.W.	1	—	—	o.	—	—
Helder	29·33	39	—	N.N.W.	8	—	—	s. o.	—	5
Dunkirk ..	29·61	41	—	N.N.W.	8	9	W.N.W.	r.	—	6
Brussels ..	29·53	37	—	S.S.W.	6	7	S.S.W.	b.	—	—
Strasburg ..	29·51	46	—	N.	4	3	W.	r. o.	—	—
Paris	29·59	38	—	N.	3	6	W.S.W.	o. f. c.	...	—
Boulogne ..	29·49	37	—	N.N.W.	7	8	N.W.	o.	—	5
London	29·63	32	—	N.N.E.	3	5	N.W.	c. o.	...	—
Yarmouth ..	29·55	37	—	N.N.E.	6	6	N.N.E.	r. c.	0·42	5
Scarborough ..	29·65	36	—	N.	6	8	N.N.E.	h. c.	0·04	5
Shields	29·71	33	—	N.W.	4	6	N.W.	s.	...	4
Aberdeen ..	29·73	27	—	N.N.W.	2	4	N.N.W.	s. c.	0·13	3
Nairn	29·82	28	—	N.N.W.	2	5	E.N.E.	c. s. o.	0·04	3
Ardrossan ..	29·85	32	—	N.	3	3	N.N.E.	b.	...	2
Holyhead ..	29·74	37	—	N.N.E.	6	9	N.N.W.	c.	...	5
Valentia ..	29·89	37	—	N.N.E.	1	3	N.E.	b.	...	2
Penzance ..	29·73	39	—	N.	1	7	N.N.E.	r. c.	0·16	3
Plymouth ..	29·72	36	—	Z.	0	3	N.W.	c. b.	0·11	3
Portsmouth ..	29·66	34	—	N.E.	3	4	N.N.W.	o. c.	...	2
Havre	29·57	37	—	N.E.	4	9	W.N.W.	o. r.	—	4
Cherbourg ..	29·65	37	—	N.N.E.	6	6	W.N.W.	o. r.	—	5
Brest	29·65	39	—	N.N.E.	5	5	N.W.	r. c.	0·08	4
L'Orient ..	29·53	39	—	N.	3	4	W.N.W.	c. o.	...	4
Rochefort ..	29·49	46	—	N.E.	4	4	N.W.	r.	0·20	2
Limoges ..	29·45	46	—	N.	3	4	N.W.	r.	...	—
Montauban ..	29·47	48	—	N.	3	3	S.	r.	—	—
Bayonne ..	29·41	50	—	E.	2	3	N.W.	r.	—	6
Bilbao	29·47	54	—	S.W.	3	—	—	o. r.	—	2
Madrid	29·69	48	—	S.W.	6	—	—	o.	—	—
Cette	29·68	48	—	N.E.	5	3	S.	c.	—	4
Lyons	29·59	46	—	N.E.	4	3	S.	f.	—	—
Marseilles ..	29·55	50	—	—	—	3	S.	—	—	—
Toulon	29·53	50	—	N.E.	6	2	W.	r.	—	6
Leghorn ..	29·71	52	—	S.E.	2	—	—	o.	—	0
Rome	29·75	55	—	S.	3	—	—	o.	—	4
Naples	29·86	54	—	S.W.	6	6	W.S.W.	r.	—	7
Ancona	29·59	56	—	S.S.E.	2	—	—	o.	—	4
Lesina	29·78	58	—	S.E.	5	—	—	f.	—	6
Trieste	29·69	46	—	S.E.	3	—	—	f.	—	1
Vienna	29·64	29	—	W.	3	5	S.W.	c.	—	—
Odessa	29·57	36	—	S.	3	—	—	c.	—	6
Nicolaief ..	29·65	39	—	S.	5	—	—	o.	—	—

INSTANCE II.

January 17–21, 1868.

The instance which it is now proposed to consider has been chosen partly as occurring at the same season of the year as the preceding, but under dissimilar thermal conditions, and partly as exhibiting an interesting type of a depression system, passing from its secondary into its tertiary stage after reaching the European coast, and undergoing dissipation in the usual irregular manner. To these advantages may be added another of some importance, *viz.* that we possess useful supplementary intelligence relative to portions of the system as they existed upon the Atlantic surface to the West of the British Isles. For these latter we are indebted to one of the admirable logs of Captain J. A. Martyn, whose steam-ship 'Sidon' encountered the S. Western arc of the circulation in her passage from New York to Liverpool. The log alluded to is one of the series published by Captain Toynbee, F.R.A.S., the Marine Superintendent of the Meteorological Office, in his Report to the Committee of the Office in 1869.

During the first week of the January of 1868, atmospheric disturbances on a very large scale existed over the more Western portions of the North Atlantic, and simultaneous depressions, with heavy snow and rainfalls, occurred in Northern Italy and the Mediterranean, while an extensive area of high pressure, with direct circulation, was located over the extreme N. and N.W. of Europe. The former series of disturbances gradually worked their way towards the E. and N.E., until on the 9th and 10th of the month their outlying Southerly currents began to be heavily felt upon our Western

shores. This was the commencement of a period of violent atmospheric perturbation over the British Isles, which continued for more than a fortnight, culminating in the remarkable Southerly hurricane which swept over the North of Britain on the 24th. The system selected for description passed over our islands in the midst of this period of agitation.

Previous to its approach the temperature of Western Europe was considerably above the mean height for the season, but France and Germany were considerably colder than the British Isles, and the general inclination of the isothermals was from N.N.W. to S.S.E. across the N. West of Europe.

On the 14th and 15th a very extensive depression passed to the Eastward across the extreme North of the British Isles, while pressure continued high in Central Europe. On the latter day the 'Sidon,' in lat. 40° 40′ N., long. 39° 40′ W., passed into the N. Western arc of an extremely intense depression, the barometer falling to 28·50, with a N.E. gale, force 11, accompanied with heavy rain. This system appears to have travelled with a Northward translation (in accordance with the temperature conditions prevailing in January over that part of the Atlantic), the wind backing to N.W., and subsequently, as the vessel advanced Eastwards, to W., and pressure recovering upwards of an inch in twenty-four hours. On the 16th and 17th a node of very high pressure existed in the S.E. of France, with brisk direct circulation, Westerly winds being experienced in Germany, the Tramontane in Italy, and S. and S.E. breezes in the Bay of Biscay, while an extensive depression again existed to the North of Scotland. On the evening of the 17th, the 'Sidon,' in long. 28° W., appears to have been near the centre of a depression,

which advanced, somewhat more rapidly than the vessel, to N.E.

Plate XXV. exhibits this latter system at 8 A.M. of the 18th, when its central portion lay off the N.W. coast of Ireland, and the currents of its S.E. arc were rushing as a violent equatorial upon our shores. At this time the 'Sidon' was experiencing a N.W. gale, with clear weather, in lat. 48° 0′ N., long. 25° 3′ W., from which point the 29·50 isobaric takes a wide curve to the Cornish coast, whence it trends N. Eastwards across England and the German Ocean to the Baltic. The high pressures being maintained on the Continent, the intensity of the system is very great, the gradient from Cape Clear being ·186 per 50 geographical miles to Brest, and ·130 to Lyons. The atmospheric conditions exhibited are highly typical of those commonly prevalent in N. Western Europe during a "S.W. storm."

The expansion of the area now became very rapid. During this day rainfall exceeding ·50 in. occurred over the greater portion of England and Scotland, while in parts of the Southern counties the fall was upwards of an inch, and in some districts of Wales upwards of 1½ in. At the Scotch stations the wind backed to S.E., while at the entrance of the Irish Channel it veered to W., blowing a most violent gale.

The S.W. storm now extended to the Continent, with heavy rain in France, where pressure gave way with great rapidity. The Easterly current, with continuous rain, began to be felt in Norway, where the diminution in pressure was greatest.

At 8 A.M. of the 19th, pressures had given way over the whole of Northern Europe, and the conditions were those of an exceedingly expanded depression, the minimum being in Denmark. To the West of this

region gradients were rather low, pressure continuing to diminish over the English Channel and in France, where the Westerly current continued to precipitate in large amount. Over the British Isles generally the rainfall was diminishing, particularly in the North, and the currents were becoming less violent. In Lancashire and Cumberland, however, there was very great precipitation, with a local in-rush of violent S.W. squalls in the Irish Sea.

Plate XXVI., for the morning of the 20th, furnishes a fair illustration of the Western portion of a very extensive system of retrograde currents in process of disintegration. Precipitation has been almost entirely arrested in the North of the British Isles: it continues at the entrance of the Channel, and over the North and West of France; and towards this district currents of increasing tension and lower temperature are being attracted from the North. The actual baric minimum had now advanced to the Gulf of Bothnia, but pressures had become low over the whole of Central Europe, with irregular currents.

On the following morning (see Plate XXVII.) the disintegration is almost complete, comparative baric uniformity having been attained over Western Europe. Winds in the North and West have become light and variable, with rather low and irregular temperatures. A feeble circulation is noticeable around the Lancashire watershed.

At noon a fresh storm system, with exceedingly copious precipitation, approached our Western coasts.

METEOROLOGICAL REPORTS.

JANUARY 17 1868.—8 A.M.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Nairn	29·19	45	—	W.	2	1	E.S.E.	c. o. h.	0·30	2
Aberbeen	29·27	46	—	S.W.	1	6	S.	r. b.	0·25	3
Leith	29·40	49	—	S.W.	6	8	S.W.	r. c.	0·04	—
Ardrossan	29·44	48	—	S.S.W.	6	9	S.W.	r. c.	0·21	5
Greencastle	29·41	47	—	W.S.W.	4	7	S.W.	r. o.	0·17	—
Valentia	29·59	50	—	W.	4	12	S.	f. l. c.	0·72	5
Cape Clear	29·60	48	—	W.S.W.	6	9	S.W.	m. r.	0·11	5
Roche's Point	29·61	49	—	S.W.	6	7	S.W.	m. o.	...	5
Liverpool	29·68	51	—	W.S.W.	4	5	S.E.	c.	...	2
Holyhead	29·62	49	—	S.W.	6	9	S.	r. o.	0·10	—
Penzance	29·90	53	—	S.W.	6	8	S.S.W.	r. m.	0·20	5
Brest	30·08	52	—	S.W.	6	7	S.S.W.	f. r.	0·04	6
L'Orient	30·12	48	—	S.S.W.	6	5	S.S.W.	f. o.	0·04	5
Rochefort	30·32	48	—	S.S.E.	2	2	S.	f.	...	4
Corunna	30·35	54	—	N.E.	3	—	—	b.	—	2
Plymouth	29·91	52	—	S.W.	9	9	S.S.W.	r.	0·25	6
Weymouth	29·94	50	—	S.S.W.	7	8	W.	m. f. r.	0·19	5
Portsmouth	29·96	50	—	S.W.	8	8	S.S.W.	r.	0·07	7
London	29·93	51	—	S.W.	7	9	S.W.	o. r.	0·01	—
Yarmouth	29·87	51	—	S.S.W.	4	8	W.	o.	...	3
Scarborough	29·64	52	—	S.W.	4	6	S.W.	c. o.	...	3
Shields	29·57	50	—	N.W.	5	7	N.W.	c.	...	2
Helder	29·92	43	—	S.W.	7	—	—	—	—	5
Brussels	30·14	49	—	S.S.W.	—	—	—	o.	—	—
Paris	30·27	42	—	S.	2	—	—	o. r.	—	—
Strasburg	—	39	—	S.W.	3	—	—	c.	—	—
Lyons	30·59	38	—	N.E.	—	—	—	c.	—	—

2 P.M.

Nairn	29·23	46	—	S.W.	1	—	—	o.	—	2
Scarborough	29·57	51	—	S.W.	3	—	—	c. o.	—	3
Penzance	29·80	52	—	W.S.W.	8	—	—	m. r.	—	6
London	29·82	53	—	S.W.	7	—	—	r. o.	—	—
Paris	30·17	48	—	S.	2	—	—	o.	—	—

JANUARY 18, 1868.—8 A.M.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Nairn	29·12	40	—	S.S.W.	1	5	S.W.	o. r.	0·10	2
Aberdeen	29·10	41	—	S.W.	2	1	W.	c. b.	...	2
Leith	29·12	46	—	S.S.W.	4	6	S.S.W.	r. o.	0·12	—
Ardrossan	29·03	47	—	S.E.	8	6	S.W.	c. r.	0·09	7
Greencastle	28·75	43	—	S.	6	7	W.S.W.	c. r.	0·07	—

JANUARY 18, 1868.—8 A.M.—*continued.*

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Valentia ..	28·93	56	—	S.W.	10	11	W.	b. r.	0·77	9
Cape Clear ..	28·91	52	—	W.S.W.	10	10	N.W.	m.	0·62	8
Roche's Point	28·94	49	—	S.W.	9	9	S.W.	o.	0·70	7
Liverpool ..	29·40	47	—	S.S.E.	5	5	S.W.	o.	0·16	3
Holyhead ..	29·22	45	—	S.S.W.	10	6	E.	o. r.	0·21	—
Penzance ..	29·55	50	—	S.S.W.	9	10	S.S.W.	m. r.	0·40	7
Brest	29·84	50	—	S.W.	8	7	S.W.	r. f. o.	0·04	6
L'Orient ..	29·96	48	—	S.S.W.	6	6	S.S.W.	o.	0·12	5
Rochefort ..	30·20	48	—	S.	3	3	S.S.E.	c. m.	...	2
Corunna ..	30·28	54	—	S.W.	6	—	—	c.	—	8
Plymouth ..	29·64	49	—	S.W.	10	9	S.W.	o. r.	0·21	6
Weymouth ..	29·65	49	—	S.S.W.	8	8	S.W.	o. f. r.	0·11	6
Portsmouth ..	29·71	47	—	S.W.	8	9	S.W.	r. o.	0·10	7
London	29·73	46	—	S.W.	7	10	W.S.W.	r. b. o.	0·12	—
Yarmouth ..	29·73	42	—	S.	6	8	W.	r. o.	0·46	3
Scarborough ..	29·47	41	—	S.S.W.	3	5	S.W.	o. r. c.	0·24	3
Shields	29·32	46	—	S.W.	3	2	S.W.	c. o.	...	2
Skudesnæs ..	29·26	46	—	S.	2	5	S.W.	c.	—	3
Helder	29·78	41	—	S.W.	3	—	—	—	—	5
Brussels ..	29·98	46	—	S.S.W.	7	—	—	c.	—	—
Paris	30·08	43	—	S.W.	2	—	—	o.	—	—
Strasburg ..	—	46	—	E.	3	—	—	c.	—	—
Lyons	30·47	41	—	S.E.	—	—	—	f.	—	—

2 P.M.

Nairn	28·64	42	—	S.S.E.	1	—	—	o. s.	—	2
Penzance ..	29·24	51	—	W.S.W.	8	—	—	r.	—	7
London	29·25	49	—	S.	8	—	—	r.	—	—
Scarborough ..	28·91	45	—	S.S.E.	8	—	—	r. o.	—	5

JANUARY 19, 1868.—8 A.M.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Nairn	28·76	41	—	N.W.	1	2	S.	o.	0·01	3
Aberdeen ..	28·72	41	—	N.N.W.	2	7	S.S.E.	b. r. c.	0·61	4
Leith	28·76	43	—	W.	2	6	S.S.E.	r. c.	0·21	—
Ardrossan ..	28·85	44	—	N.W.	2	5	S.S.E.	r. c.	0·51	2
Greencastle ..	28·90	45	—	N.	1	9	W.N.W.	c. r. o.	0·22	—
Valentia ..	29·16	46	—	N.W.	9	12	W.	r. l. c.	0·13	8
Roche's Point	29·08	43	—	W.	7	8	S.W.	o.	0·23	5
Liverpool ..	28·86	44	—	W.S.W.	5	8	W.S.W.	c. r.	0·13	3

JANUARY 19, 1868.—8 A.M.—*continued.*

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rain-fall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Holyhead ..	28·83	45	—	S.S.W.	6	11	S.S.W.	o. r.	0·33	—
Penzance ..	29·30	47	—	W.N.W.	9	9	S.W.	r. l. c.	0·60	7
Brest	29·49	45	—	W.	8	9	S.W.	h. f. r.	0·32	9
L'Orient ..	29·57	46	—	S.S.W.	7	8	S.S.W.	o. b.	0·91	8
Rochefort ..	29·76	46	—	S.W.	4	7	S.W.	r. m.	0·24	5
Corunna ..	30·04	54	—	S.W.	6	—	—	m.	—	8
Plymouth ..	29·26	44	—	W.N.W.	10	10	W.S.W.	r. c.	0·80	8
Weymouth ..	29·22	46	—	W.	6	10	S.W.	o. r. b.	0·75	5
Portsmouth ..	29·18	45	—	W.S.W.	6	11	S.W.	r. c.	0·56	6
London	29·06	42	—	W.S.W.	7	10	S.S.W.	r. h. o.	0·63	—
Yarmouth ..	28·95	45	—	W.S.W.	4	10	S.	r. c.	0·33	5
Scarborough ..	28·75	41	—	W.	4	9	W.	r. o. c.	0·16	4
Shields	28·78	43	—	N.W.	5	8	N.W.	c. r. o.	—	3
Skudesnæs ..	28·37	39	—	E.	5	5	S.S.W.	r.	—	5
Helder	28·90	42	—	W.S.W.	4	—	—	o.	—	5
Brussels ..	29·20	44	—	W.S.W.	—	11	—	c.	—	—
Paris	29·69	43	—	W.S.W.	7	—	—	b.	—	—
Strasburg ..	—	48	—	W.	6	—	—	o.	—	—
Lyons	29·83	50	—	S.	—	—	—	c.	—	—

JANUARY 20, 1868.—8 A.M.

STATION.	Barometer.	Thermom.		Wind.		Extreme Wind.		Weather.	Rain-fall.	Sea.
		Dry.	Wet.	Direction.	F.	F.	Direction.			
		°	°							
Nairn	29·30	31	—	W.N.W.	1	2	N.E.	o. c.	0·07	2
Aberdeen ..	29·23	33	—	N.	1	4	N.N.W.	s. b.	0·05	4
Leith	29·18	35	—	N.	2	2	W.	o. b.	...	—
Ardrossan ..	29·24	37	—	N.N.W.	3	1	N.W.	c.	...	3
Greencastle ..	29·22	38	—	E.S.E.	3	1	N.	c. o.	...	—
Valentia ..	29·18	45	—	N.	2	7	N.W.	r. c.	0·25	3
Cape Clear ..	29·11	45	—	N.W.	3	8	N.W.	m. c.	0·35	3
Roche's Point	29·08	40	—	W.N.W.	5	7	W.S.W.	o. c.	...	4
Liverpool ..	29·14	40	—	E.	4	5	S.E.	c. f.	0·03	2
Holyhead ..	29·06	45	—	E.N.E.	2	11	S.S.W.	o. c.	0·36	—
Penzance ..	29·00	42	—	N.E.	4	10	W.N.W.	o. r.	0·35	5
Brest	29·02	46	—	W.N.W.	9	7	W.	h. r.	0·37	9
L'Orient ..	29·06	46	—	W.	7	7	W.	r.	0·47	8
Rochefort ..	29·25	50	—	W.	7	8	W.	r. m.	0·59	7
Plymouth ..	29·00	40	—	N.E.	2	10	W.N.W.	c. r.	0·20	5
Weymouth ..	29·03	42	—	N.E.	3	10	S.W.	o.	0·05	4
Portsmouth ..	29·00	40	—	E.	2	8	W.	r. m.	0·02	1
London	29·04	41	—	N.E.	2	8	S.W.	c. r. o.	0·05	—
Yarmouth ..	29·08	40	—	N.E.	5	8	W.S.W.	r. c.	0·21	4
Scarborough ..	29·15	38	—	N.E.	3	1	N.N.W.	c.	0·07	4
Shields	29·18	36	—	N.E.	2	2	N.W.	c.	0·25	3

JANUARY 20, 1868.—8 A.M.—*continued.*

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rain-fall.	Sea.
		°	°							
Skudesnæs ..	28·81	33	—	N.W.	7	5	E.N.E.	c.	—	5
Helder	29·07	39	—	W.N.W.	3	—	—	c.	—	2
Brussels ..	29·05	44	—	S.S.W.	7	—	—	o.	—	—
Paris	28·96	38	—	E.?	6	—	—	o. r.	—	—
Strasburg ..	—	41	—	S.W.	3	—	—	o.	—	—
Lyons	29·37	46	—	S.W.	—	—	—	o.	—	—

2 P.M.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rain-fall.	Sea.
Nairn	29·34	33	—	S.W.	1	—	—	c. b.	—	1
Greencastle ..	29·35	38	—	S.E.	1	—	—	o.	—	1
Valentia ..	29·34	46	—	N.	3	—	—	r. o.	—	8
Penzance ..	29·33	48	—	N.	4	—	—	o. r. c.	—	5
London	29·23	48	—	N.E.	2	—	—	o.	—	—
Scarborough..	29·27	40	—	N.E.	3	—	—	c.	—	5

JANUARY 21, 1868.—8 A.M.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rain-fall.	Sea.
		°	°							
Nairn	29·50	28	—	S.S.E.	1	1	W.N.W.	c. b.	...	1
Aberdeen ..	29·54	27	—	W.	1	1	N.	b.	...	2
Leith	29·56	36	—	N.W.	1	1	N.	b. f.	...	—
Ardrossan ..	29·58	37	—	N.	1	2	N.N.E.	s. c.	...	1
Greencastle ..	29·59	35	—	W.N.W.	1	3	E.	o. s. b.	0·09	—
Valentia ..	29·71	41	—	W.	2	10	N.	h. r. o.	0·12	3
Cape Clear ..	29·69	40	—	S.W.	2	5	N.W.	m.	...	2
Roche's Point	29·68	37	—	W.N.W.	4	6	W.N.W.	o. b.	...	3
Liverpool ..	29·62	41	—	S.E.	3	4	E.	r.	0·22	1
Holyhead ..	29·59	42	—	W.N.W.	4	3	E.N.E.	o.	0·13	—
Penzance ..	29·79	44	—	N.N.W.	2	4	N.E.	r. o. c.	0·17	3
Brest	29·84	45	—	N.N.W.	6	7	W.N.W.	r. f. c.	0·20	6
L'Orient ..	29·80	43	—	W.N.W.	3	4	N.N.W.	b.	0·08	5
Rochefort ..	29·88	43	—	W.	3	8	W.	r. b.	0·16	7
Plymouth ..	29·74	39	—	Z.	0	3	N.E.	b. m.	0·08	3
Weymouth ..	29·73	43	—	W.	1	4	N.E.	o. m.	0·03	3
Portsmouth ..	29·71	38	—	S.S.W.	3	2	N.E.	o. m.	...	2
London	29·72	36	—	S.S.W.	2	3	N.E.	c. b. o.	...	—
Yarmouth ..	29·71	34	—	N.E.	4	8	N.	o. m.	...	4
Scarborough..	29·62	33	—	S.W.	2	3	N.E.	c. h. f.	...	3
Shields	29·58	34	—	S.W.	2	2	N.W.	c. m.	...	2
Skudesnæs ..	29·43	30	—	N.N.W.	2	5	N.N.W.	c.	—	3

JANUARY 21, 1868.—8 A.M.—*continued.*

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
		°	°							
Helder	29·65	38	—	W.N.W.	4	—	—	—	—	1
Brussels ..	29·76	38	—	S.W.	—	—	—	c. m.	—	—
Paris	29·86	32	—	N.W.	2	—	—	b. m.	—	—
Strasburg ..	—	39	—	N.N.W.	3	—	—	o.	—	—
Lyons	29·92	46	—	N.	—	—	—	c.	—	—

2 P.M.

Station.	Barometer.	Thermom. Dry.	Thermom. Wet.	Wind. Direction.	Wind. F.	Extreme Wind. F.	Extreme Wind. Direction.	Weather.	Rainfall.	Sea.
Nairn	29·47	38	—	S.W.	1	—	—	b.	—	1
Greencastle ..	29·53	38	—	N.W.	1	—	—	b. m.	—	—
Valentia ..	29·39	44	—	S.	6	—	—	r.	—	4
Penzance ..	29·70	57	—	S.S.W.	5	—	—	o. r.	—	4
London	29·71	43	—	S.	3	—	—	o. m.	—	—
Scarborough..	29·60	36	—	W.S.W.	2	—	—	c.	—	3

CHAPTER IX.

UPPER-CURRENTS.

We have confined our attention hitherto principally to certain horizontal movements of the atmosphere taking place upon the immediate surface of the earth, because it was desirable to avoid the complexity which an earlier consideration of the phenomena of Upper-currents might have introduced into our discussion, while at the same time it seemed possible, without reference to these, to investigate up to a certain point the laws of the winds on the earth's surface. Beyond this point, however, it would be difficult to proceed without an examination of some of those phenomena of the higher atmospheric regions whose existence appears to be based on sufficient evidence.

The mention of Upper-currents recalls to the meteorologist the extent of that ignorance in which we still lie of a large proportion of the processes taking place in the fluid which surrounds us. The motions of its lowest surface we are capable of registering correctly, and reducing with a certain degree of accuracy to fixed and definable laws, the data for such inquiries being abundant and unexceptionable. But directly we undertake the examination of those currents which prevail at a considerable altitude, we find ourselves engaged with an investigation the materials of which are comparatively meagre and unsatisfactory, and with a subject in which conjecture and hypothesis have occupied to a great extent the place of ascertainable fact.

The materials which might appear capable of use towards the discovery of general laws in this branch of meteorology are reducible to: I. observations of atmospheric currents made on the summits of lofty mountains, II. aeronautic observations, and III. observations of the direction and apparent rapidity with which the higher strata of clouds are seen to move.

Of these classes the first may be dismissed with the remark that in our own regions of the globe we have no Teneriffe to supply us with convenient data for the investigation of our variable upper-currents.

The second has contributed a number of highly valuable and important facts relative to the temperatures, velocities, &c., of currents at considerable altitudes, and the elevation of the various cloud strata; but the paucity and isolated character of such observations render it impossible to draw from them the requisite generalizations.

We are reduced, therefore, to those observations of the motions of elevated clouds which have been made from the earth's surface. But here we encounter a difficulty at the outset in our absence of information as to the elevation of the clouds observed. It is a well-known fact that not only do clouds at a distance from the earth's surface frequently move in a different direction to that of the surface-currents, but that several cross-currents very commonly prevail, various atmospheric strata moving at the same time in various directions. Consequently, in comparing the results of his observations made at different times, the observer cannot be sure that his investigations do not refer to strata of very diverse altitudes. Still more difficult is it to derive satisfactory conclusions from simultaneous observations of upper-currents made in different localities, as the

various observers may be similarly contemplating clouds of different elevations.

Owing to this and other difficulties, no attempts appear to have been hitherto made to systematize the results of upper-current observations, with a view to ascertain the relations existing between the directions and velocities of such currents and the distribution of pressures at the earth's surface.

In the absence of such investigations, endeavours have been made to explain many of the less intelligible phenomena of the lower-currents by conjectural theories regarding the processes simultaneously occurring in the higher regions, and the upper-current has been employed by meteorologists as a sort of *Deus ex machinâ*, to explain the obscurities of the science.

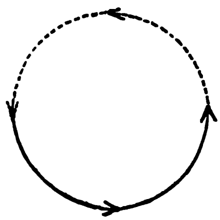
Thus Maury,* supposing the general circulation of the atmosphere in the temperate zones to be precisely analogous to that existing in tropical regions (only in a contrary direction) assumed the existence of a prevalent polar upper-current, carrying back the atmosphere which has been transferred poleward by the under-current. And the assumption is indeed necessitated by the theories of the surface-currents adopted by himself and by Fitz-Roy, according to which not merely are atmospheric disturbances propagated towards the poles, but there exists an actual molecular transference of the lower portions of the atmosphere in that direction. To account for the usual poleward progression of the revolving storms in the temperate zones, Fitz-Roy supposed them to be driven towards the poles by a prevailing tropical current acting as a *vis a tergo*, and if such a supposition be correct it is obvious that the atmosphere thus transferred to the poles must

* 'Physical Geography of the Sea,' § 121–§ 139.

somehow return as an upper-current towards the tropics.

Similarly later observers have suggested, as an explanation of the apparently common phenomenon of hemi-cyclones (*i. e.* strong S.W. and N.W. currents with no S.E. or N.E. currents on their polar sides) the hypothesis of an inclination of the cyclone's axis causing the tropical side to touch the earth's surface, while the polar is at a considerable altitude; an hypothesis which so far, no doubt, agrees with fact, that the dry and cool Northerly and N. Westerly winds have a *descending*, and the warm and rainy Southerly and S. Westerly an *ascending* tendency.

Fig. 9.



The want of the requisite data makes it difficult either to prove or disprove theories of this kind. They demand as the condition of their demonstrability that actual observation should detect the existence of the prevailing polar or Easterly upper-current.

The writer has been for many years convinced that by the collection and analysis of a very extensive series of observations of the highest clouds, some of the difficulties attending this branch of the science might be removed. He does not assert that his own researches will have accomplished this result, which requires in an especial degree a combination of prolonged investigations by numerous observers; yet he ventures to hope that the data which he has accumulated, some of the results of which will be presently stated, may at least prove suggestive, and perhaps furnish the basis of future inquiries. For more than ten years he has made numerous observations every day, whenever the conditions of the atmosphere permitted, on the direction and

rapidity of the upper-currents, and in this task he has been from time to time assisted by the labours of a few friends who have made simultaneous observations in other localities. In order to eliminate as far as possible the errors resulting from the variety of the cloud altitudes, the observations to which the following remarks will apply are *entirely* confined to the motions of clouds of the true *Cirrus* type, these being the highest clouds ever observable, and occupying a stratum of atmosphere which, there is reason to believe, is subject to no excessive variations of altitude. The object to which attention has been especially directed is this,—to ascertain *whether any general relation exist between the motions of this stratum of air and the conditions and distribution of atmospheric pressures at the surface of the earth, and,* if so, *what that relation is?*

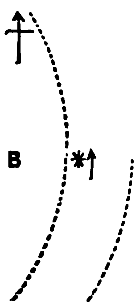
For a long period the results arrived at appeared highly variable and unsatisfactory, but as exhibited in the following Table, certain general laws appear distinctly traceable amidst the maze of the upper-current variations.

Direction of Upper-currents.

Six hundred and twenty observations upon the motions of Cirrus clouds have been selected for examination, and these have been classified according to their position at the time of observation with respect to the neighbouring centres of high or low pressure. The principle of the classification adopted can most easily be explained by the aid of a couple of diagrams, in which the asterisk denotes the locality of observation, the dotted lines the neighbouring isobarics (determined from Meteorological Reports), and the arrow the direction

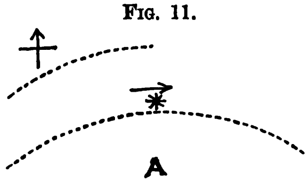
of the upper-current. Thus in Fig. 10 the observation is made upon the East limit of an area of depression, pressure being lowest in the direction of B, round which point the isobarics tend to sweep. The direction of the arrow would in this instance be in accordance with Ballot's law (and therefore in general agreement with the motion of the surface-wind, which would be about South). If the arrow in this case were reversed, the upper-current being from due N., it would be in direct opposition to Ballot's law. If the upper-current over the place of observation travelled from a S.W., W., or N.W. point, it would be said to be inclined *from* the depression centre; if from a S.E., E., or N.E., it would be said to be inclined *towards* the depression centre.

FIG. 10.



In Fig. 11 the observation is made upon the North limit of an area of high pressure, pressure being greatest in the direction of A, round which point the isobarics tend to sweep. Here again the direction would be in accordance with Ballot's law, being from W. to E. On the other hand a due E. upper-current would be in direct opposition to the law, a N.W., N., or N.E. would be inclined *towards*, a S.W., S., or S.E. *from* the centre of highest pressure.

FIG. 11.



The observations have been divided upon this principle into eight classes, the first four being made in the quadrants of circular (or approximately circular) areas of depression, and the last four in the corresponding quadrants of similar areas of high pressure.

It was necessary in making the selection to discard a very large number of upper-current observations, *viz.* those made in intervening calms, or in the central calms of high or low pressure, and likewise those whose class it appeared difficult to determine, either on account of the complexity or irregularities of pressure distribution, or because the observer was so located that it was not possible to decide whether he could be said to be in the segment of a low-pressure system existing on the one hand, or in that of a high-pressure system existing on the other, no curvature being discoverable in the isobarics immediately over the region of observation.

CLASS I.—N.E. to S.E., LIMIT OF DEPRESSION AREA.

	Instances.	Percentage. (Approx.)
In accord with Ballot's law	31	33·3
In opposition to Ballot's law	2	2·2
Inclined towards depression centre	5	5·4
Inclined from depression centre	55	59·1

CLASS II.—S.E. to S.W., LIMIT OF DEPRESSION AREA.

In accord with Ballot's law	54	48·2
In opposition to Ballot's law	1	·9
Inclined towards depression centre	16	14·3
Inclined from depression centre	41	36·6

CLASS III.—S.W. to N.W., LIMIT OF DEPRESSION AREA.

In accord with Ballot's law	46	55·4
In opposition to Ballot's law	4	4·8
Inclined towards depression centre	14	16·9
Inclined from depression centre	19	22·9

CLASS IV.—N.W. to N.E., LIMIT OF DEPRESSION AREA.

In accord with Ballot's law	4	7·4
In opposition to Ballot's law	6	11·1
Inclined towards depression centre	4	7·4
Inclined from depression centre	40	74·1

CLASS V.—N.E. to S.E., LIMIT OF HIGH-PRESSURE AREA.

In accord with Ballot's law	37	56·9
In opposition to Ballot's law	2	3·1
Inclined towards highest pressure	15	23·1
Inclined from highest pressure	11	16·9

CLASS VI.—S.E. to S.W., LIMIT OF HIGH-PRESSURE AREA.

	Instances.	Percentage. (Approx.)
In accord with Ballot's law	10	15·2
In opposition to Ballot's law	11	16·6
Inclined towards highest pressure	35	53·0
Inclined from highest pressure	10	15·2

CLASS VII.—S.W. to N.W., LIMIT OF HIGH-PRESSURE AREA.

In accord with Ballot's law	13	22
In opposition to Ballot's law	4	6·8
Inclined towards highest pressure	40	67·8
Inclined from highest pressure	2	3·4

CLASS VIII.—N.W. to N.E., LIMIT OF HIGH-PRESSURE AREA.

In accord with Ballot's law	26	29·6
In opposition to Ballot's law	1	1·1
Inclined towards highest pressure	50	56·8
Inclined from highest pressure	11	12·5

The above Tables incidentally furnish some suggestions tending to the solution of the questions previously touched upon, regarding the prevalence and position of polar upper-currents. The examination of the Tables proves a great preponderance, generally, of W. over E. upper-currents, while no preponderance of either S. over N., or N. over S. upper-currents is very distinctly traceable. The fact, indeed, that the observed Westerly upper-currents prevail over the observed Easterly upper-currents, even more than the Westerly surface-winds do over the Easterly surface-winds, has been admitted by most of the observers who have investigated the subject in different parts of Western Europe; and the same phenomenon is noticed in similar latitudes of North America. Observed N. Easterly upper-currents are almost rarities in the British Isles. The effect of this generalization is modified, though not, I think, neutralized, by a suggestive remark of Fitz-Roy that polar upper-currents may exist *unobserved* with comparative frequency, their dry atmosphere carrying visible water-vapour only on rare occasions. Be this

as it may, the theory of prevalent polar upper-currents derives no support from our own collection of examples.

Again, the results of the observations classified in Table IV. appear altogether adverse to the supposition that an Easterly upper-current is common over the Northern portions of those depression systems whose Westerly winds are the strongest at the earth's surface. The percentage of upper-currents in accordance with Ballot's law should here, according to that supposition, be the highest; yet it is precisely in this class that it is the lowest. Instead of Easterly upper-currents (the Northern arc of the supposed inclined cyclone), we find a great preponderance of Southerly currents, while in a few examples the upper-current moves in a direction parallel with the isobarics, but with the lowest pressure on the *right* of its course.

The phenomenon, however, to which I would call attention as having its existence demonstrated in the Tables is this: In whatever position we stand relatively to the centres of highest or lowest pressure (with one exception presently to be considered), we find the motions of the upper-current more commonly inclining from the lower towards the higher pressures than in the contrary direction. Combining the aggregate of examples in the eight classes, we find the number of instances of the former inclination to be as 295 to 73 of the latter.

Or again, combining the *percentages* in the preceding Tables, and thus equalizing in effect the aggregate number of observations in each Table, we have as a result,—

> The relation between the number of instances in which the upper-currents incline from low to high pressures, and that in which they incline from

high to low pressures is as 393 : 92 (or about 4 to 1).

We thus arrive at the important general law connecting the direction of the higher currents with the distribution of atmospheric pressures at the earth's surface.

"*The higher currents of the atmosphere, while moving commonly with the highest pressures, in a general way, on the right of their course, yet manifest a distinct centrifugal tendency over the areas of low pressure, and a centripetal over those of high.*"

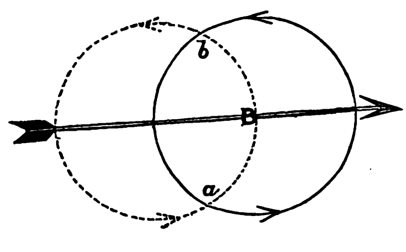
This tendency is the more noticeable as being the contrary of that which prevails in the motion of the surface-winds. The latter, when deviating from a parallelism with the isobarics, incline in a large percentage of examples towards lower and from higher pressures, and the contrary deviation (when not traceable to local peculiarities of the earth's surface, &c.) is uncommon.

Inclination of Depression Axis.

To return to the Tables from which the law of upper-currents was deduced. It will be noticed that it is in Classes I. and IV., or in the East and North segments of areas of depression, that the upper-currents incline most uniformly from the depression centre, and that it is in Classes II. and III. (and especially the latter), or in the West and South segments, that we find the highest percentages of upper-currents inclining towards the depression centre. The observation of this fact having led to a closer examination of the instances making up these latter percentages, it was found that by far the greater number of them occurred in the S.W. and S. sides of the depression areas, and that

here, *when at no very great distance from the central calms*, the upper-current inclined more frequently *towards* than *from* the depression centre. Most observers who have at all made the motions of the higher currents their study will have noticed that immediately after heavy rain from the S.W. or S., with a low barometer, when the under-current has shifted to W. or N.W. and the sky has cleared, the upper-currents are still found in most cases to travel from a point S. of W., and that the veering of these latter to W. or N.W. takes place a few hours subsequently to the change of the surface-wind. This fact again leading to further investigations, it was discovered that the position in a depression area in which the upper-currents most directly and persistently flow towards the centre of depression commonly depends on the direction in which the depression itself is progressing. With depressions travelling to East, the phenomenon is commonly observed a little to the S.W. of the centre; with those taking a more Northerly course, it is most noticeable in the S. or S.E. The conclusion arrived at is this, *that the axis of a progressive retrograde circulation commonly inclines backwards*, so that the extremity nearest to the earth's surface is the first in each case to enter the regions to be traversed. The point *a* in the diagram marks the district in which the upper-current will commonly flow most directly towards the region of lowest pressure.

FIG. 12.



At a distance of three or four hundred miles from the centre of depression this tendency of the upper-

current commonly ceases to be traceable, and the current either flows parallel with the isobaric, or inclines from the centre.

Theoretically, the district marked *b* in the diagram should be that in which the upper-current will commonly flow most directly out of the region of lowest pressure. The comparative paucity, however, of the instances in which a centre of depression passes on the immediate S.E. of an observer in the British Isles, coupled with the ordinarily overcast state of the sky when it does so, has prevented any satisfactory proof that this is practically the case.

Variation of Upper-currents.

Of the exceptions to our law of upper-currents a certain number are referable to the phenomenon just described. There are, however, a multitude of other variations.

It would seem that some depression systems, when in the earlier stages of development, and when not of very great geographical extent, scarcely affect the motions of the upper-currents in their vicinity in any perceptible degree. The atmospheric disturbance is in these cases confined to the lower strata of the atmosphere, and the motions of the higher continue as they were previous to its development, and are dependent upon the distribution of the more distant and extensive pressure centres. As an example we may refer back to the storm of Feb. 12, 1869.* In that instance the Cirrus-current over the district of Great Britain traversed by the disturbance was scarcely affected at all, moving from W.S.W. in the front of the area of circu-

* P. 68.

lation, and from W. by N. and W.N.W. in its rear, and being dependent on an extensive Scandinavian depression. In such examples it is obvious that observations made in the four quadrants of the minor depression tend to equalize in the Tables the percentages of upper-currents inclined from and towards the depression centre, as well as of those in accordance with and in opposition to Ballot's law.

Again, there occur at rare intervals in Western Europe depression systems which affect, but in a very singular way, the directions of the upper-currents, reversing them so that they become, on all sides of the area, nearly, or quite, in opposition to Ballot's law, that is to say, there exists a direct upper-current circulation above a retrograde circulation of the surface-winds. The depression system selected as our second instance* exhibits this characteristic in a remarkable degree. Instances of this type, exceptional as they are, tend to affect the general result in the Tables of percentages. They are, however, extremely suggestive, and throw considerable light on the connection between the upper and lower circulation in depressions.

It is important to observe that these examples furnish no proof that Ballot's law *may not be true*, or approximately so, *in every case, for the particular stratum of atmosphere to which it is applied.* Thus it is quite conceivable that on the afternoon of February 12, 1869,† at an elevation of four miles above the earth's surface, pressures may have been equal along a belt stretching W. and E. across the English Midlands, the rarefaction of the atmosphere near the earth not being communicated to the higher regions. There is nothing in the physical conditions of the atmosphere to render the

* P. 86. † Plate VII.

supposition absurd, that a great rarefaction near the surface of the earth may even coincide with a slight accumulation in the higher districts. Thus, on the afternoon of March 19, 1869,* at a great elevation, the tension of the atmosphere may have been greater over the West of England than at the same elevation over Scotland and Ireland.

Theory of the Upper-currents of Depressions.

We must return for a moment to the consideration of the phenomena accompanying the primary development of depression systems, partially described in Chap. IV. We there saw that although the ultimate effect of precipitation is to increase the atmospheric pressures, dry air being heavier than damp, yet its immediate result is a considerable diminution of pressure. If moist air contained in an air-tight vessel have a portion of its vapour withdrawn, there will of course result a diminution of the weight of the air equal to the weight of water withdrawn. On the occurrence of very extensive precipitation the portion of atmosphere existing over some hundreds of square miles of the earth's surface bears an approximate resemblance to the air in such a vessel, because the aqueous vapour precipitated cannot at once have its place supplied by the in-flowing draughts from the exterior of the area, these being thrown into a helix by the axial rotation of the earth. When the resulting rarefaction has become considerable, the attenuated atmosphere tends to rise, and ascending columns of dry, warm, and light air are established above the focus of the depression. These currents continue during their ascent to gyrate in accordance with the motion

* Plate XI.

originally imparted to them when near the earth's surface, and that frequently with great velocity, being freed from the obstructions of the surface. Having attained their appropriate level they incline to flow off in all directions from the axis of the depression, having their place constantly filled by fresh ascending columns from below, and themselves settling down towards the regions from which the new surface-currents have to be drawn.

When the depression is progressive, as is commonly the case, the precipitation of aqueous vapour in the lower regions of the atmosphere being rapidly propagated in one direction or another over the earth's surface, the summit of the ascending air column is left considerably behind the base. A perpendicular section of such an upper-current circulation would bear some resemblance, if figured, to the representation of a large flattened mushroom, having a somewhat inclined stem.

In a horizontal direction the most prevailing tendency of the upper-currents at a distance from the axis of the depression will be to flow off at a tangent from the axis, but this motion will itself be immediately affected by the influence of the earth's rotation, until, at a greater or less distance from the central area, the circulation approximates to the *direct* type. *E.g.* the current which rises while travelling from S.E. will continue at first to flow as an upper-current towards N.W., trending gradually to N. until at length it appears to flow to N.E. That which rises as a S.W. current will similarly become a Westerly, and finally a N. Westerly upper-current. Thus when a decrease of pressure is accompanied by S.E. or E. winds, the first upper-currents are commonly observed to move from a S. Westerly or Westerly point, and these presently back towards S.E. as the depres-

sion proceeds. On the other hand, with a falling barometer and rainy winds from S. or S.W., the upper-current in a majority of examples is found to travel at first from some point between N.W. and W., subsequently backing towards S.W. or S. as the disturbance advances.

Attention cannot fail to be drawn to the analogy existing between the phenomena of each local area of depression and those which characterize the great depression belt of equatorial calms, the in-flowing currents of which, after ascending in a rarefied condition, roll off at a great altitude as upper-currents, first towards N. and S., and subsequently towards N.E. and S.E. in the direction of the high-pressure belts of Cancer and Capricorn.

Velocity of Upper-currents.

Both in the scientific examination of the wind systems, and in the prognosis of atmospheric changes the study of the direction of the highest currents is of a value which cannot be overrated. But, as in the case of the surface-winds, the velocity is an element of as much importance as the direction of the currents. It would be of great advantage if some scale could be adopted for the measurement of the relative velocities of the motions of the Cirrus clouds; the object of such a scale being twofold: 1st, to enable us to approximate to the determination of the actual velocities of the currents; and, 2ndly, to render it possible, by simultaneous observations in different localities, to discover the quarters in which an increase or diminution of force commences, to detect the existence of ascending and descending currents, and to determine to some extent their position.

The altitude of clouds of the true Cirrus type is subject to variation; being ordinarily somewhat greater in summer than in winter, and with very high than with very low pressures. This variation, while making it impossible to obtain with precision the actual from the apparent rapidity of the currents, is not of a kind to interfere with the comparisons of simultaneous observations.

The time occupied by these clouds in passing from the zenith to 45°, or the contrary, furnishes us with a standard of measurement which is both convenient for simultaneous observations, and also possesses this obvious advantage, that whenever the altitude of the cloud-stratum is at all determinable, none but the simplest of calculations is required in deducing the actual from the apparent velocity.

The ordinary range of the actual rapidity of this current is about twice as great as that of the rapidity of the surface-winds, for while the latter, at situations most fully exposed to their violence, rarely attain, in Europe, a velocity of more than 60 or 70 miles an hour, the most elevated clouds not uncommonly traverse a distance of 120 miles an hour, and occasionally much more. The majority of instances in which very high velocities have been observed over the British Isles were in autumn, winter, and spring, and occurred when great but distant depressions existed in the N.E., in Scandinavia or Finland, and when the direction of our upper-current was from N.W. or N.N.W. The backing upper-current already alluded to as existing over the Eastern arc of an advancing depression is also sometimes of extreme velocity when from a N. Westerly or Westerly point, and appears to be especially so when the depression is of great intensity, and therefore when

the equatorial surface-wind is about to attain a very high force. In summer the most rapid upper-currents are, in a majority of instances, from Southerly points.

Calms, on the other hand, are extremely uncommon in this elevated stratum, at least in those instances in which it supports visible water-vapour. I have only once or twice observed an actually motionless Cirrus cloud, and it is on rare occasions that an hour is occupied in passing from the zenith to 45°. A condition of baric equilibrium in this stratum is commonly most nearly approached in summer, and near the centres of areas of high pressure.

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